ACTA PARASITOLOGICA POLONICA
VOL. VI WARSZAWA, 15.I.1958 FASC. 1

Department of Parasitology, Warsaw University
Head: Prof. Dr. Wincenty L. Wiśniewski

Wincenty L. WIŚNIEWSKI

Characterization of the parasitofauna of an eutrophic lake

[Parasitofauna of the biocoenosis of Drużno Lake — part I]

Charakterystyka parazytofauny jeziora eutroficznego

[Parazytofauna biocenozy jeziora Drużno — część I]

Contents

Introduction 1
Problems 2
The characterization of Drużno lake 5
Methods of collecting materials 12
The hosts and their parasites 20
Conclusions and final remarks 53
I The importance of various hosts 53
II The focal occurence of parasites 57
III The contributions of typical species 59
IV The invasion in an eutrophic lake 59

Introduction

A research organized by the Department of Parasitology, Chair of Biology, Warsaw University, into the parasites of the biocoenosis of Drużno Lake was carried out in 1950, 1951 and 1953. Those taking part in the research were the permanent staff of the Department some undergraduates of the University of Warsaw Faculty of Biology and the Science of the Earth, serving their summer holiday zoological apprenticeship, and occasionally, members of the staff of other Institutes.

The results of the examination of the materials collected will be published under the common title "Parasitofauna of the biocoenosis of Drużno Lake". The studies are written by various authors and deal with parasites of vertebrates (fish, amphibians, birds) as final hosts and parasites of various invertebrates as intermediate hosts. The present study opens the series and discusses the methods applied and the material of hosts and their parasites.

I wish to extend my warm thanks to all my fellow-workers, who contributed, in a larger or smaller measure, to the elaboration and collection of the materials. The work spelt much self-denial and devotion, a good deal of physical and nervous effort on their part, as the conditions of work at the lake were not easy. In particular, I thank the following persons, who helped with the elaboration of this study by collecting the materials: Miss W. Chodorowska, mgr K. Dobrowolski, mgr L. Jarecka, mgr Z. Kajak, mgr S. Kozłowski, doc. dr J. Kozicka, dr A. Krzanowski, mgr H. Klimaszewska, mgr J. Pinowski, mgr K. Rybicka, mgr E. Styczyńska, mgr T. Sulgostowska, mgr T. Biesiakierska-Tarwid. Considerable help was also offered by mgr L. Ryszkowski, mgr K. Tarkowski, Mr. J. Dmoch and others.

The research was team work and all fellow-workers took part in the collection of the materials, which largely hastened the work and allowed more material to be collected, and experiences and comments were mutually exchanged during its elaboration. Undoubtedly it was thanks to the collective character of the work that a huge material of hosts was examined and a great number of parasites were collected in a relatively short time.

The research was continued for three years. It was conducted during three seasons of the year in the first two years. It expanded over 9 and 10 days in spring, 87 and 78 days in summer in 1950 and 1951 respectively, and 11 days in autumn each year. A total of 107 days were devoted to observations and collecting materials in the field in the first research year and another 99 days in the following year. In this way materials were collected for two years in three different seasons of the year, which helped to explore the occurrence of parasites in annual cycles. The 1953 research was carried out from July to late in September and partly in November, and was devoted mainly to the examination of development cycles.

Problems

The parasitological research taken up at Drużno Lake had several problems in view.

1. The problem of the circulation of parasites in the Drużno Lake biocoenosis was the most important of them. What is meant by this?

As is known, representatives of very many parasitic groups pass through definite development cycles during which one and the same specimen develops the successive stages of its ontogenesis in various hosts. The passing of a given parasite through all of its successive hosts terminates its life cycle and enables it to produce a new generation. Now it is the passing of larvae from one host to another, and then to still another, under natural conditions that I call the circulation of parasites in a biocoenosis.

An accurate determination of the order of hosts for definite parasite species had for years been the object of researches of a great number of writers. All researches in this field had been characterized by two features. First, they dealt with definite single parasitic species, and then, they were restricted to laboratory conditions, i.e., they were carried out outside the biotopic conditions specific to a definite host. Such procedure is necessary in a certain stage of methodology. Yet it should be borne in mind that research going on in this direction can help us to explore the development cycle of a given parasite without giving us any idea of how this cycle is realized under natural conditions in a biotope or a biocoenosis in which the parasite occurs. The cycle may undergo various shifts in relation to the type of biotope, and, consequently, to the character and composition of biocoenosis, and this may eventually result in a picture sometimes quite different from that obtained in laboratory conditions.

It may also be anticipated that the circulation of parasites in natural conditions is based upon definite quantitative relations in a given biocoenosis. In addition to methods practicable in experiment, factors have to be reckoned with here which are eliminated in laboratory work, such as the mutual influence of the environmental factors on the quantitative occurrence of proper hosts, the distribution of intermediate and final hosts, the presence or absence of vicarious hosts, and perhaps, other interdependencies. The whole of the process of the larvae passing from one host to another in succession in natural conditions in of a far greater complexity and variability than the same process taking place under the laboratory conditions of experiment. It is directed not by an experimentator but by specific biological regularities and regulated by physico-chemical factors of environments which no experimentator may ensure.

The first problem taken up at Drużno Lake was to explore the circulation of parasites within the fauna of this large sheet of water

and to examine whatever regularities may be revealed in the process. It was an attempt at investigating into interdependencies between the biocoenosis of this body of water and its parasitofauna.

It ought to be added however that the circulation of parasites in Drużno Lake does not exhaust the problem. The final elaboration of the results of the research should find the answer to its fundamental question: do any differences exist in the circulation of parasites in various types of lake-like bodies of water and in what do they consist?

On close analysis, the problem may be ultimately reduced to the question to what extent the character of a body of water influences that of its parasitofauna. As is known to every type of body of water are related a specific composition and distribution of its biocoenosis. These are different for every type, oligotrophic, mezotrophic, eutrophic, distrophic, or intermediate. Its parasitofauna is related to the composition of a biocoenosis, hence the parasitocoenosis of a given type of body of water may have a definite qualitative composition or definite numerical relations. Taking these moments into account we can formulate the problem in its final version as follows:

— given the type of a body of water and its biocoenosis, can we anticipate the occurrence of definite parasitic species, and, in particular, can we say what may occur and in what parts of the lake?

An answer in the affirmative would be of great importance from the point of view of practical (e.g., fishing) diagnostics.

Before the problem as posed above may be solved I think it necessary:

— to know the channels through which parasites circulate in a definite biocoenosis,
— to know the characteristic properties concomitant to the circulation,
— to know the channels through which parasites circulate, their properties, and regularities in various types of bodies of water and in various biocoenoses of these lakes.

Starting from such assumption we must admit that the research carried out at Drużno Lake constitutes only a part of a far wider problem. It may solve only a part of it, that is to say, explore the channels of circulation, and perhaps, find out what are the most essential characteristic properties of the circulation through various hosts in a biocoenosis, as represented by Drużno Lake. The Drużno fragment must be extended to other types of bodies of water and

their biocoenoses and may complete a whole exhaustive of the problem only when we know the channels of circulation in various types of bodies of water and biocoenoses as well as regularities governing the circulation of parasites. The object of the present work therefore is to examine the properties of the parasitofauna characteristic of an eutrophic body of water.

2. Another topical problem at Drużno Lake was to examine the life cycles of flukes, tapeworms, and thorny-headed worms. This examination was made experimentally and it was based on fieldwork observations. It aimed at verifying the working hypotheses on the channels of the circulation of the parasites examined in the biocoenosis. On examination of the abundand material of final and intermediate hosts, traces of fragments of various life cycles of flukes and tapeworms were found. The assumed cycles required confirmation by experiment. Thus the development cycles of some fluke species were described by Wiśniewski [29, 30], of some tapeworms by Jarecka [7] and Rybicka [18], and of one species of thorny-headed worm by Styczyńska [22].

3. The problem of the quantitative regulation of hosts by parasites was the third research item. Here belong Kozicka's observations of the influence of parasites on fish. The observed pathogenic effect of some parasitic forms, larval fluke forms in parrticular, on the small fish population led to the discovery of one of the reasons for losses in fisheries. Other pathological and pathogenic symptoms were also observed which had been rather inadequately treated in literature before.

4. Problems specific to a given taxonomic group constituted the fourth group of subjects. They dealt with a closer characterization and a more detailed description of the species already known or newly found in the Drużno Lake biocoenosis. They are anatomo-morphological and taxonomical problems and were treated in special studies by Jarecka, Kozicka, Rybicka, Sulgostowska and Wiśniewski.

The characterization of Drużno Lake

Drużno Lake was chosen as the site of the research for three reasons:

1. The lake lies on the migration route of birds. Huge numbers of birds meet there of which a large proportion are indificant. The

lake was declared a bird reservation as early as before World War I and has continued as such.

2. The lake communicates through the Elbląska river, deepened and widened so as to be a canal, with Vistula Bay. This connection results in an exchange of fish between the lake and the bay, particularly when the lake is frozen over or in spring, when migrations of fish from the bay to the lake were observed.

3. The lake is strongly eutrophized and to stress its strong eutrophization, vegetation and shallowness, some compare it to a huge pond.

Thus, the lake abounds in final hosts, birds and fish, and this consideration decided its choice for the site of the research.

The lake is shallow throughout and has the littoral character. It shallowness accounts for the fact that it was even described as a fluvial expansion or a „pond-lake" (Mikulski, 1955).

Drużno is situated in the North of Poland at a distance of 4 km from Elbląg and about 15 km from Vistula Bay. It is a big lake and reaches 10 km in length, while its width varies from 0.5 km to 2 km. It looks like a long bent gut with a maximum width in its southern part. A narrowing about half-way along the lake divides it into two sections: north-western and southern. This division is purely morphological, since from the point of view of the physico-chemical properties and the composition of the biocoenosis, both sections differ little from each other, and the whole lake ought to be treated as an ecological unit.

Given its length and width, one may still find it difficult to determine the area of the lake. It is swampy, particularly in its southern part, and surrounded with swamps and the vegetation growing on them. It is difficult to draw a dividing line between the bank, swampy and overgrown with vegetation, and the mirror of the water, and, accordingly, the area of the lake is estimated at anything from 1 930 ha to 3 900 ha by various authors. These large differences in the estimation of the area, amounting to nearly 300 per cent, are not surprising, considering that Drużno is almost completely overgrown with vegetation advancing from its bank and bottom. From late spring to autumn only $^1/_3$ to $^1/_2$ of the mirror of the water may be seen, the rest being hidden under luxuriant aquatic vegetation. The picture changes only with the coming of autumn, when the lake seems to emerge from under the vegetation which dies away, and reveals the expanse of its waters. According to Steiniger

(1938) the area of the lake amounts to 16 km^2 of water and 15 km^2 of swamp. These measurements seem to be the most accurate as far as the relation of water and swamp to each other is concerned.

Drużno is a shallow lake, 1 to 1.5 m deep on the average, and only the navigation canal traversing the whole of it reaches a depth of 4 m. There are deeper places throughout this shallowness, even on the whole, outside the canal. These are large and small hollowings, difficult to locate accurately, where usually more fish occur.

The lake is fed by a few small rivulets which empty into it mainly in the south and the east. The supply of water from these is small. Somewhat more water is supplied by the pumps transferring water from the drainage canals. This is not a great quantity after all, since the water of the lake penetrates back to the surrounding wet meadows and swamp lying below the level of the lake. The water thus continues to circulate between the lake and the swamps, meadows and adjoining fields. Snails, insects, and possibly other faunistic components, heavily and richly occurring in the canals and fields, pass with the water through the pumps. The annual rainfall is not very high and amounts — according to Schultz (1941) — to 600 to 700 mm; most of it comes in the summer months. In ultimate calculation the amount of water supplied to the lake by its tributaries of all kinds and rain is relatively not very large. Under the circumstances, the Elbląska river flowing from the lake and Vistula Bay, lying almost at the same level as Drużno Lake, have become the main source of its supply of water and brought about changes in the level of water in the lake. If winds blow from the north, the raised waters of the bay turn the current of water in the canal and flow into the lake. A south wind causes the water distinctly to ebb from the lake. Daily differences in the level of the water were sometimes observed to amount to 50 cm and more during a few days in summer; they are even bigger in autumn and spring. According to the data for 1948—1951, differences between the minimum and maximum levels of the water of the lake at the Żukowo port, situated on the west bank about half way down the lake, amounted to 1.3 m. The influence of the bay on the height of the water of the lake depends first of all on the winds, their strength and direction. The north and northwest winds, prevailing particularly in spring and autumn, raise the waters of the bay and influence the level of the lake water through the canal. When all these factors are

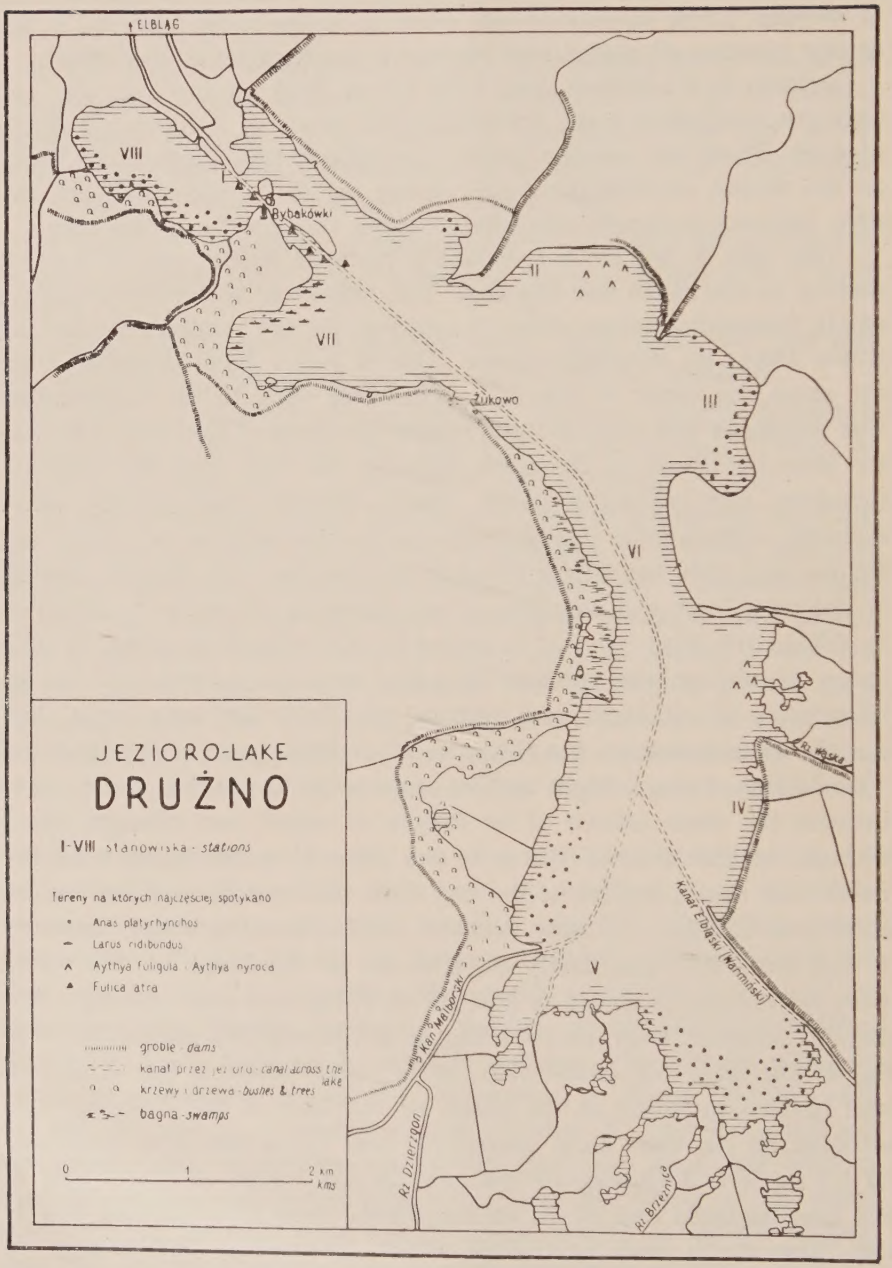

ELBLĄG
VIII
Rybakówki
VII
II
III
Żukowo
VI
IV
V
JEZIORO-LAKE
DRUŻNO
I-VIII stanowiska - stations
Tereny na których najczęściej spotykano
Anas platyrhynchos
Larus ridibundus
Aythya fuligula i Aythya nyroca
Fulica atra
groble - dams
kanał przez jez. oraz - canal across the lake
krzewy i drzewa - bushes & trees
bagna - swamps
0
1
2 km
kms
Kanał Elbląski (Warmiński)
Rz. Dzierzgoń
Rz. Brzezina

Fig. 1

taken into consideration, it may be assumed that the level of the water at Drużno depends first of all and chiefly on the winds.

The bottom of the lake is slimy. According to Schultz (1941), an exploration carried out by the National Prussian Geological Institute indicated, broadly speaking, that the gross sand, lying at a depth of 10 to 12 m, constituted the base of the basin of the lake. On it there was a layer of peat (Bruchwaldtorf) under 1 m thick at same places and up 2 m at others. This was covered in turn by masses of fine loam and organic compounds making up a stratum 8 to 10 m in thickness. Anything passing from limestone to plankton gytia might be found there, the latter constituting the lower and upper strata, and the limestone gytia making up the mid one. Shells of *Valvata piscinalis, V. naticina, Bithynia tentaculata, Pisidium nitidum* and *Ostracoda* might be found in it. On closer examination *Diatomeae* were found in many samples.

The bottom of the lake is all overgrown by vegetation, but there are a few clear patches, not of any considerable expanse, at it. The bottom could be compared in summer time, as it is by some authors, to a flooded meadow whose prolific vegetation makes invisible not only the banks covered by *Typha, Phragmites, Scirpus, Nymphea, Nuphar*, etc., but also the waters of the mid lake filled with immersed, floating plants and reeds. Free from vegetation is only the artificial canal running lengthwise of the lake and bifurcating three quarters through the length of the lake into the Warmiński and the Malbork Canals (Fig. 1). There is poorer vegetation, too, in front of the mounths of the four rivulets on the south-east side and there are sandy or loamy strips at the bottom there.

This vegetation dies away year in year out and, by mixing constantly with loam, it forms loose slime very rich in detritus. Its surface is covered here and there with a mass of *Lamellibranchia* and *Gastropoda* shells numerically out of proportion to the discovered number of living animals. One of the reasons why their numbers is increased is the fact that masses of molluscs are brought along by the pumps from the drains adjoining the lake.

In the postglacial period Drużno and its western neighbourhood with the Vistula Delta were an area which the sea repeatedly invaded and receded from. It might also have been cut by the many branches of the Vistula Delta. Changes also occurred in the historic period. They consisted above all in the Nogat striking across the area and finding new beds. The sands and small rivulets and canals

are remnants of the movements of the river. A certain stabilization of the area came only with the construction of protective walls on the western side of the lake in the days of the Knights of the Cross. The eastern side of the lake, surrounded by the Elbląg elevation was less exposed to topographical changes.

The extent of the lake underwent fairly distinct changes in the historic period. On the evidence of maps Lüttschwager (1925) compared various phases in the process of the lake getting grown over and shrinking. It follows from the comparison that the lake shrank mainly in its southern part. Its southeast part decreased because of the alluvial deposits from the rivulets, and its south-west part shrank because of the spread of vegetation. The northern part has remained unchanged for the last 350 years at least. This is rather difficult to explain, considering the advanced process of eutrophization. The most plausible explanation is the impact of the sea on vegetation reflected in various phenomena of which one is the far poorer occurrence of duck-weed in the northern part of the lake. The influence of the sea undoubtedly became more distinct when the Elbląžka river was deepened and changed to a canal. By stopping or advancing the senescence of the lake in its northern part at least the sea keeps up the life of Drużno.

The lake was explored by a number of botanists (Kalmus, 1884; Tessendorff, 1909, 1916, 1921). The most exhaustive of recent studies was written by Schultz (1941). It follows from the characterization given by Schultz and the observations made by Mowszowicz (1954) that while the vegetation of the lake has the optimum conditions of development, a limited number of species is characteristic of it. *Typha angustifolia, T. latifolia, Sparganium ramosum* and *Phragmites communis* occupy the first place here and by covering considerable areas lend a characteristic appearance to the banks of the lake. *Scirpus lacustris* is far less common and occurs in tufts of medium size at various places.

Of superaqueous plants, masses of *Nymphea candida, N. alba, Nuphar luteum* and *Limnanthemum nympheoides* may be found. Subaqueous floral plants (*Myriophyllum verticillatus, Ceratophyllum demersum, Stratiotes aloides*) from vast subaqueous meadows hampering the progress of a motor-boat at times. Single specimens of *Elodea canadensis* may be found among them, the plant being scanty and seemingly oppressed at the lake.

The following superaqueous plants occur near the banks: *Hydro-*

charis morsus ranae, *Spiradella pollyrrhiza*, *Lemna minor*, *L. giba*, and *L. trisulca*, the latter species occurring submersed in the water and attached to other plants.

Of submersed plants forming large accumulations, there are various species of pondweeds, such as *Potamogeton obtusifolius*, *P. lucens* and *P. prelongus*.

I mention only the most characteristic representatives of the lake flora which occur abundantly. A more detailed enumeration would not essentially contribute to the characterization of the lake from the parasitological point of view. It follows from Schultze's findings that the flora of the lake has become distinctly poorer since 1933. He ascribes the reason for this to the changes of the chemical composition of the water due to pollution from the town sewers.

As regards the occurrence of vegetation, the biocoenoses are more or less balanced in spring. The luxuriant grows of vegetation in summer brings about a differentiation of various points into stations. During the autumn investigations the vegetation of the stations became poorer in turn. This was reflected in some degree in the fauna taken from one square metre of the bottom surface and the flora growing on it.

In summer time the sampling points were overgrown with the following plants:

No. of samples		Plants
1950	1951	
4	1	*Nymphea alba*
4	3	*Nuphar luteum*
2	1	*Juncus* sp.
4	1	*Stratiotes aloides*
2	1	*Typha angustifolia*
3		*N. alba* + *Sparganium ramosum*
3	1	*N. alba* + *St. aloides*
3		*N. luteum* + *St. aloides*
3		*N. luteum* + *Myriophyllum verticillatus*
1		*Typha angustifolia* + *Sp. ramosum*
1		*M. verticillatus* + *Ceratophyllum demersum*
1		*M. verticillatus* + *Hydrocharis morsus ranae*
2		*Sp. ramosum* + *M. verticillatus*
1		*N.alba* + *St. aloides* + *T. angustifolia* + *M. verticillatus*
1		*N. alba* + *Sp. ramosum* + *M. verticillatus*
1	1	*N. luteum* + *Phragmites communis* + *St. aloides*
1	1	*N. luteum* + *Sp. ramosum* + *Ceratophyllum demersum*
1	1	*T. angustifolia* + *Elodea canadensis* + *C. demersum*
	1	*St. aloides* + *C. demersum*

As vegetation varied from one sampling point to another, differences might be observed in the proportion of various animal species in each, particularly when leeches were picked up. No accurate analysis of dependence of animals on the plant species was made, since this lay outside the object of the research.

Methods of collecting materials

Below are given only the general methodical principles applied in the collection of host material and the assessment of the parasites collected. Special methods of collecting, preserving and treating parasites of various taxonomic units and culturing methods applied in the research work are described in individual studies.

To solve the problem of the circulation of parasites in the biocoenosis the following principles were adhered to:

1. Attempts were made to establish and determine the composition of the biocoenosis;
2. Within determined biocoenotic composition attempts were made to determine the composition of the parasitofauna;
3. Attempts were made to determine the composition of the biocoenosis and its parasites at the same time;
4. The material was collected by quantitative methods and supplemented by the qualitative method, if the quantitative method could not be exhaustive and adequate.

The above directional methodical principles ought to be explained. Thus, as regards the determination of the composition of the biocoenosis, it is noteworthy that no accurate and exact reproduction of quantitative faunistic relations was practicable. This applies above all to avifauna and ichthyofauna. As far as these elements of the Drużno biocoenosis were concerned, it was possible to determine their specific composition, but quntitative findings left room for doubts as to the accuracy of the method adopted and the observations made. Consequently all that was done was to single out dominants, i.e., most common, leading species, lending characteristic features to the biocoenosis. Limited to this extent, the subject assumed a practicable form. Yet beside looking for parasites in these dominants, representatives of other species of fish and birds were also examied, though in smaller quantities and as a secondary problem.

To single out the most characteristic elements of an avifauna and ichthyofauna is of particular importance from the point of view of the circulation of parasites, as fish are intermediate hosts of ma-

ny flukes and tapeworms, and birds are their final hosts in their life cycle. It may be anticipated that where there occur definite bird species, this may affect the parasitofauna of fish.

Links formed by the fauna of amphibians and invertebrates are another very essential moment in the determination of the occurrence of parasites. They supply a food basis for many species of birds and fish, and are intermediate hosts of many parasites. The above faunistic factors were determined for Drużno Lake as well.

Within the singled-out biocoenotic composition, the composition of parasitofauna was determined on the evidence of an abundant material. In this material, the parasitic species typical of the Drużno biocoenosis as well as those constituting an incidental element were defined. The intensity and extensity of invasion were the criteria of the frequency of occurrence and typicality.

The determination of the fauna of hosts and their parasites was simultaneous and parallel with each other. This is a very important methodical moment, since unless hosts and their parasites are picked up at the same time, it is impassible to obtain an accurate picture of the circulation of parasites. Work here cannot be limited to one year or one season of the year only. Therefore the explorative research consisted in examining the host material for parasites for two years, during three seasons each year. The research of the first year aimed at making a list of dominant hosts and their main parasites, while its object in the second year was to confirm or supplement, if necessary, the observations of the first. As differences in the composition of the biocoenosis and parasites between the two years was stated at the same time, it was easier to decide which of the parasites was more typical of the biocoenosis. The research of the third year was devoted to special problems, above all to supplementing the materials and experiments concerning the development cycles of flukes and tapeworms.

The character and object of the research made it necessary to use quantitative methods with the help of which it was possible to single out characteristic and leading parasites. The material collected by the quantitative method also, or perhaps first of all, lends itself to analysis of the circulation of parasites. Without numerical data on hosts and their parasites it is impossible to determine the possibility of invasion of larval forms in the successive stages of their life cycle or the characteristic properties of various stages of the circulation.

The qualitative method is of a supplementary character in investigations of this kind. First of all, it makes it possible to detect the components of the biocoenosis occurring less frequently yet of considerable importance either in the alimentary chain or as a regulating factor in the biocoenosis (e.g., predators). In these less frequent hosts parasites are also found sometimes in great quantities and highly differentiated which may constitute an important component of a parasitofauna. Thus, among the molluscs collected by the quantitative method 36 species of cercariae were found most of which undoubtedly rank among the species most characteristic of the biocoenosis. They are not however all species of cercariae found in the lake, since of the snails collected by the qualitative method, another eighteen, i.e., one third of the species recorded in the area, were added.

A criterion in the form of the qualitative method proved to be even more necessary in the exploration of the parasitofauna of aquatic insects, since the percentage of invasion among insects was so low that if the quantitative method only had been applied, it would have allowed no relations in the development chain to be discovered. The material of hosts and parasites showed a focal distribution in the lake in many cases, and this circumstance rendered it necessary to collect the material by the qualitative method as well. If the quantitative method only had been used the picture of the composition of the parasitofauna would not have been proper or full. It was with the above assumptions that both methods were applied to the collection of material at Drużno.

A unit of measure had to be decided on, but it proved impossible to establish one measure of reference. It was a square metre for the benthos, a cubic one for the plankton and a unit of time for birds. As regards fish, the figures for catches for several years were resorted to and on this basis the conclusion on the frequency of occurrence of various species were reached.

Lack of uniform reference as a quantitative measure is undoubtedly a serious methodical shortcoming but I could not see if any uniform comparative criterion might have been applied. Althought these criteria of measurement varied from one another, they served their essential purpose, i.e., they made it possible accurately to determine the quantitative composition of the biocoenosis and its parasitofauna.

The method of determining the composition of the biocoenosis and parasites in various classes of hosts is as follows:

Birds

The observations of the lake avifauna were at first made from a motor-boat but is was found later on that more accurate observations might be made from a canoe. In the first year attempts were made to define the avifauna in relation to the surface of the lake; but this proved impossible. The avibiocoenosis evinces little stability and moreover the observations at Drużno Lake were hampered by the lake being overgrown with vegetation. Under the conditions, some of the bird species, e.g., swans, could be easily observed and determined accurately even at a long distance, while others could not. These circumstances told unfavourably, in a varying degree, on the quantitative determination of the avifauna per unit of surface. Consequently, stress was laid on counting the number of birds per unit of time in the second year (1951). The number of birds observed during one hour's slow canoeing was accepted as a criterion. Two environments were distinguished at the lake to make observations easy:
— the edge of the reeds with adjacent floating vegetation,
— the clear or scarcely overgrown water surface far from the reeds.

In the time observations two calculation methods were used which aimed at securing control and a more accurate quantitative estimation. The first consisted in counting birds while canoeing past the edge of the reeds, with all its nooks and corners, round the lake. This procedure gave us a general idea of the number of birds of a given species. It took twenty-three hours to travel all round the edge of the reeds. This general picture was made more accurate by the application of the second method, which consisted in making detailed observations at each of the stations near the bank. Of all observations made in the littoral environment an average was calculated for various species per observation hour. The results thus obtained were multiplied by the quota of hours it took to canoe near the edge of the reeds all round the lake. These results roughly coincided with the data obtained during a single round past the banks of the lake. Birds on the open waters were observed in a similar manner. It took ten hours to tour this environment in zigzag.

July and August, i.e., a period of intense research, are the months most difficult for ornithological observations because of moulting. This entails not only inaccuracy in determination at a distance but

also the risk of missing birds hiding in the reeds. To make the observations more accurate, it was necessary to calculate the percentage of birds escaping the observer's attention. In comparing the day-time results with early morning observations, a correction was accepted increasing e.g., the number of *Anatidae* and *Fulica atra* observed by 50 %, or reducing e.g., the number of *Larus* and *Sterna* observed by 25 %, since one and the same bird might have been counted several times. In this way the percentage of each of the species was calculated in relation to the total of birds occurring in the environments distinguished. For all this cautiousness, it was accepted that the error in calculation for some species, *Anatidae* in particular, might have been rather large, and when the total of birds was calculated, it was stated to vary fairly greatly.

Fish

The determination of the composition of the ichthyofauna was based on the catches obtained by a Fishing Station of the Warsaw Agricultural Academy, which was in charge of the fisheries at the lake till 1951. The percentage of occurrence for various species was calculated and the typical representatives of the ichthyofauna singled out on the evidence of the figures obtained from eng. M a l i c k i, Head of the Station. The basis of the calculation was supplied by the fish material caught in five years (1947—1951) in various seasons. Thus, although objections may be made to the calculation method on the ground that it is selective and of little accuracy, the vastness of the material (about 45 tons of fish) and the recurrence of species in the catches makes the results thus obtained considerably more accurate. At all events the method allows the dominant species to be singled out. These were:

Esox lucius	— 33%;
Rutilus rutilus	— 25%;
Scardinius erythrophthalmus	— 13.5%;
Tinca tinca	— 10.6%;
Blicca björkna	— 7.5%;
Perca fluviatilis	— 5.4%;
Carassius carassius	— 3.5%;
Others	— 1.5%.

Amphibians

Amphibians were most awkward to collect by the quantitative method. The lake was difficult of approach and so the collection was

possible only at some points. Consequently, the research was limited to qualitative samples so that as much material as possible could be collected. Amphibians were picked up by hand, with the help of an angle or net, and under certain circumstances shot from a rifle.

Plankton

Plankton was sampled by the quantitative and qualitative methods. When the former was applied water was taken from three levels from places deeper than 1.5 m and from two levels where the depth was up to 1.5 m. Twenty litres of water were pumped out at each of the levels and this quantity was passed through a plankton net. Thus sixty litres of water were won from the deeper stations and forty litres from the shallow ones. For technical reasons it was not advisable to take more water and plankton at a time, since it was not always possible to keep more plankton alive. The water was taken by means of a foot-pump and a tin funnel through which water was drawn from a measured depth. The tube of the funnel was comparatively wide, so as to balance the escape of plankton caused by the violent current of the water drawn in by the pump. The water was pumped into a bottle of a capacity of twenty litres. The qualitative sampling calls for no detailed explanation.

Plankton was collected from eight stations of which seven were the same as for benthos (Fig. 1). Moreover one more station was chosen; it was situated on the boundary of the Elbląg Canal and the lake. It was called Station No. 1. It was the only deep station (4 m). The plankton taken from it might possibly indicate the occurrence of transition forms between Vistula Bay and the lake.

Benthos

A metal dredging-apparatus 1 m long, 0.5 m wide and 5 cm high was constructed to collect slime. It holding capacity amounted to 25 000 cm^3. The apparatus was furnished with a wing on each of its sides, 15 cm long, which prevented it from digging into the slimy bottom. The purpose of applying it instead of an Ekman was to collect material from as large an area of the bottom as possible without breaking it into separate sections. Some thought it was unwise to collect material with a dredging-apparatus as it limited the number of samples taken. That the apparatus was of little use — as explained below — was due to other reasons. The method of collecting

materials for parasitological purposes with a dredging-apparatus is right, but it requires some modification for the future.

In order to make it possible to take benthos from a square metre of the bottom, the surface of the water was separated with a wooden square metre and from within it were taken a 5 cm layer of slime and whatever vegetation grew on the surface of the bottom and inside the column of water above it. The slime was passed through a fine-meshed sieve and all *Oligochaeta, Hirudinea, Insecta* (larvae and imagines), *Asellus* and *Mollusca* were removed from it. Everything noticeable with the naked eye was also removed from the aquatic vegetation collected. The fauna removed was examined for the presence of parasitic forms. Fifty odd square metres of the bottom, the vegetation growing in the column of water above it and just as many square metres of floating vegetation were examined by this method during two years. The benthos of 50 m^2 only was analysed as this number is round and lends itself better to comparison.

The more numerous the samples taken, the greater the possibility of obtaining figures most adequately rendering the true relations existing in the fauna of a given body of water. A number of samples may however be regarded as sufficient when further samples contribute no faunistic elements and numerical relations begin to recur ever more often. The number of square metres examined at Drużno proved to be sufficient according to this criterion, the composition of the benthos and the fauna connected with vegetation being very much the same at various stations at the lake. After a considerably smaller number of samples were taken, no new species of hosts or parasites appeared. Nothing but numerical relations in the composition of hosts and parasites varied.

Beside the method described, slime was sampled with an Ekman at a few places, accepting forty samples taken with an Ekman as equivalent to the holding capacity of the dredging-apparatus. A copper net was put inside the Ekman limiting the collection of slime to a layer of 5 cm. The amount of slime and benthonic fauna living in it and checked in this manner corresponded without great errors to the data obtained from sampling slime with the dredging-apparatus.

The dredging-apparatus was used to make the collection of slime easier on the one hand and to take more hosts from one place on the other. The point was first of all more easily to catch first and

intermediate hosts, considering that the cercariae occurring in molluscs would penetrate into the larvae or mature insects, crustaceans, molluscs etc. in their neighbourhood. Hence also the necessity to sample hosts from a possibly continuous homogenous surface of the bottom or the plants growing above the place where slime was sampled. Undoubtedly the method yeilded the expected results and helped detect intermediate hosts in a number of cases, but the results appeared poorer than expected. For only a part of benthonic animals proved to be intermediate hosts of flukes in the lake. A disadvantage of the use of the dredging-apparatus was the difficulty in placing it properly at the bottom. It took much time, as a wrong location led up to taking incomplete samples and called for repetitions.

Benthonic material was collected from seven stations chosen at the lake. A station covered an area of the lake 700 to 800 m long and situated mainly on the boundary of the reeds and the clear surface of the water. It covered parts of the lake distinguished by the shape and the character of the bank, which separated them from the surroundings. There were points of diverse flora and diverse vegetable aggregates at each station. Material was sampled each time at a different point at each of the stations. Naturally, there occurred points of a similar vegetation type at various stations. A degree of differentiation was established which corresponded to the environmental differentiation in the whole lake, while material was collected at various points.

Taken as a whole the material collected at 50 different points of seven different stations did reflect biotopic relations at Drużno Lake and thus represents in miniature the relations of the benthonic biocoenosis and its parasites. However, since the stations and points did not cover the middle part of the lake the question arises whether the material may be considered representative. The test of the representativeness of the material was therefore in sampling it at the widest cross-section of the lake, i.e., between Stations VI and III. The material collected with an Ekman at the rate of 40 samples every 50 m showed that there was no quantitative or qualitative difference in hosts between the sampling points along the bank line and across the lake. The material collected at seven stations may be regarded as fully representative of the whole lake. From the point of view of the composition of the benthos and plankton fauna, Drużno is the same in littoral parts and in the middle.

The hosts and their parasites

The material was collected so as to supply parasitological needs and thus those groups were above all taken into consideration which served, or were suspected to serve, as hosts of parasites. Naturally, many taxonomic groups, such as planarians, rotatoria, free-living nematodes, spiders and others which play an important part in the circulation of parasites, were left out of account.

The host material split into two groups, the first consisting of final hosts, and the second of intermediate and first ones. As final hosts, birds, amphibians and fish were collected. Among first and intermediate hosts stress was laid on collecting snails, larvae and mature specimens of aquatic insects, crustacean plankton, leeches and oligochaets.

Because of the selection of materials for parasitological needs and owing to the method suited to the purpose, the materials may in part serve to characterize the lake biocoenotically. Without giving a full picture of the Drużno biocoenosis, they make it possible to single out the most characteristic species of birds, amphibians, fish, components of crustacean plankton and benthos, i.e. species important as main and intermediate hosts of parasites. The material collected is very abundant indeed and there may be no doubt as to its being representative.

The main idea of the characterization of the hosts was to bring out the most essential elements of the biocoenosis of Drużno Lake. To underline the dominant species was in turn a basis of finding out what parasitofauna is characteristic of the biocoenosis.

Birds and their parasites

Drużno Lake has long been known by ornithologists as a place of the greatest abundance of birds. Literature on the occurrence, nestling and numerical relations of various bird species there, as well as their biology is fairly considerable, and the lake ranks with those best explored in Mazury Lake District. It has been the object of studies of many ornithologists among whom those of Döring 1844, 1847), Homeyer (1881), Tischler (1914, 1941), Tessendorf (1917), Lüttschwager (1924—1925) and Steiniger (1938) are particularly noteworthy. They contributed abundant factual material to the knowledge of the ornithology of the lake, although nearly all of these studies suffered from their occasional cha-

Table I

Birds as hosts of parasitic worms

		Occurring in biocoenosis in 1950 and 1951		Examined 1950 1951	Not invaded	% of invasion	*Trematoda* number of		*Cestoda* number of		*Nematoda* number of		*Acanthocephala* number of	
		number	%				species	specimens	species	specimens	species	specimens	species	specimens
	Type species													
1	*Fulica atra* L.	2000—4000	35.0	60	—	100	3	140	3	2730	—	—	1	—
2	*Anas platyrhynchos* L.	2000—3000	29.0	61*	4	93	8	1175	16	24735	—	—	2	300
3	*Sterna hirundo* L.	±300	3.5	14	12	14	—	—	—	—	1	2	—	—
4	*Larus ridibundus* L.	200—300	2.5	42	2	95	5	5141	4	149	1	13	—	—
5	*Aythya nyroca* (Güld.)	200—300	2.5	23	—	100	10	2012	20	9122	—	—	2	10
6	*Chlidonias nigra* (L.)	150—300	2.5	18	12	33	2	33	2	2	—	—	—	—
7	*Anas querquedula* L.	100—300	2.5	14*	—	100	1	14	9	1103	—	—	—	—
8	*Podiceps cristatus* (L.)	±200	2.3	18	1	94	4	919	2	383	—	—	—	—
9	*Anas strepera* L.	50—200	1.2	4	—	100	1	87	4	26	—	—	—	—
10	*Rallus aquaticus* L.	50—200	1.2	2	—	100	1	1	—	—	—	—	—	—
11	*Porzana porzana* (L.)	50—200	1.2	1	—	100	1	6	—	—	—	—	—	—
12	*Ixobrychus minutus* (L.)	50—200	1.1	2	—	100	2	13	—	—	—	—	—	—
13	*Aythya fuligula* (L.)	±100	1.1	1	—	100	2	10	5	888	—	—	2	6
14	*Aythya ferina* (L.)	50—100	0.8	6	—	100	6	90	9	538	—	—	1	7
15	*Circus aeruginosus* (L.)	40—50	0.5	4	—	100	2	10	1	150	—	—	—	—
16	*Ardea cinerea* L.	±40	0.5	6	—	100	2	6	1	5	—	—	—	—
		5400—9800	87%	277	31			9957		40186		15		323
	Rare species													
17	*Acrocephalus scirpaceus* (Herm.)	100—400	2.9	—	—	—	—	—	—	—	—	—	—	—
18	*Motacilla alba* (L.)	100—300	2.5	5	3	40	—	—	1	8	—	—	—	—
19	*Acrocephalus schoenobaenus* (L.)	150—200	2.0	—	—	—	—	—	—	—	—	—	—	—
20	*Emberiza citrinella* L.	50—150	1.0	1	1	—	—	—	—	—	—	—	—	—
21	*Tringa glareola* L.	80—120	1.0	7	—	100	—	—	3	162	—	—	—	—
22	*Acrocephalus arundinaceus* (L.)	20—60	0.4	—	—	—	—	—	—	—	—	—	—	—
23	*Gallinula chloropus* (L.)	30—50	0.4	5	1	80	1	3	4	51	1	1	1	3
24	*Philomachus pugnax* (L.)	±30	0.3	5	1	80	3	37	1	66	1	1	1	4
25	*Botaurus stellaris* (L.)	±20	0.2	1	—	100	2	21	—	—	—	—	—	—
26	*Cygnus olor* (Gm.)	±20	0.2	—	—	—	—	—	—	—	—	—	—	—
27	*Nycticorax nycticorax* (L.)	12—16	0.1	—	—	—	—	—	—	—	—	—	—	—
28	*Ciconia ciconia* (L.)	10—15	0.1	—	—	—	—	—	—	—	—	—	—	—
29	*Phalacrocorax carbo* L.	10—15	0.1	1	—	100	1	17	2	901	—	—	—	—
30	*Panurus biarmicus* (L.)	6—10	0.03	2	2	—	—	—	—	—	—	—	—	—
31	*Circus pygargus* (L.)	6—10	0.03	1	—	100	—	—	1	10	—	—	—	—
32	*Alcedo atthis* L.	6—10	0.03	1	1	—	—	—	—	—	—	—	—	—
33	*Milvus migrans* (Bodd.)	2—10	0.01	—	—	—	—	—	—	—	—	—	—	—
34	*Remiz pendulinus* (L.)	2—3	0.02	—	—	—	—	—	—	—	—	—	—	—
		650—1400	11.4%	29	9			81		1193		2		7

* Data for *Cestoda* from 1950, 1951, 1953.

Table I continued

	Birds, migratory, or staying periodically at the lake	Occurring in biocoenosis in 1950–1951	Examined 1950	Not invaded	% of invasion	*Trematoda* number of		*Cestoda* number of		*Nematoda* number of		*Acanthocephala* number of	
		number				species	specimens	species	specimens	species	specimens	species	specimens
35	*Haliaeetus albicilla* (L.)	1–3	—	—	—	—	—	—	—	—	—	—	—
36	*Pandion haliaëtus* (L.)	1–3	—	—	—	—	—	—	—	—	—	—	—
37	*Milvus milvus* (L.)	1–2	1	1	—	—	—	—	—	—	—	—	—
38	*Anas crecca* L.	30–50	3	1	66	2	11	—	—	—	—	—	—
39	*Spatula clypeata* (L.)	10–20	—	—	—	—	—	—	—	—	—	—	—
40	*Anas penelope* L.	6–10	—	—	—	—	—	—	—	—	—	—	—
41	*Anas acuta* L.	2–5	—	—	—	—	—	—	—	—	—	—	—
42	*Bucephala clangula* (L.)	5–10	1	—	—	—	—	—	—	—	—	—	—
43	*Mergus merganser* (L.)	2–5	—	—	—	—	—	—	—	—	—	—	—
44	*Mergus albellus* L.	5–10	5	1	80	2	413	—	—	—	—	—	—
45	*Vanellus vanellus* (L.)	60–100	—	—	—	—	—	—	—	—	—	—	—
46	*Totanus erythropus* (Pall.)	7–10	1	1	—	—	—	—	—	—	—	—	—
47	*Tringa nebularia* (Gunn.)	4–8	—	—	—	—	—	—	—	—	—	—	—
48	*Capella galinago* (L.)	10–30	2	—	100	1	40	4	14	—	—	—	—
49	*Numenius arquata* (L.)	15–20	—	—	—	—	—	—	—	—	—	—	—
50	*Actitis hypoleucos* (L.)	20–30	—	—	—	—	—	—	—	—	—	—	—
51	*Calidris alpina* (L.)	20–30	1	—	100	—	—	2	6	1	1	—	—
52	*Calidris minuta* (Leisl).	20–50	1	1	—	—	—	—	—	—	—	—	—
53	*Limosa limosa* (L.)	4–6	1			—	—	—	—	—	—	—	—
54	*Calidrus temminckii* (Leisl.)	3–6	—	—	—	—	—	—	—	—	—	—	—
55	*Larus canus* L.	5–10	4	3	25	2	104	—	—	—	—	—	—
56	*Sterna albifrons* Pall.	2–4	—	—	—	—	—	—	—	—	—	—	—
57	*Podiceps nigricollis* (Brehm)	10–30	2	1	50	—	—	1	30	—	—	—	—
58	*Podiceps ruficollis* (Pall.)	2–4	—	—	—	—	—	—	—	—	—	—	—
59	*Podiceps griseigena* (Bodd.)	10–20	2	—	100	2	35	1	16	—	—	—	—
60	*Riparia riparia* (L.)	3000–4000	2	1	50	—	—	1	2	—	—	—	—
61	*Hirundo rustica* L.	300–400	4	2	50	1	23	1	2	—	—	—	—
62	*Sturnus vulgaris* L.	4000–5000	3	1	66	—	—	1	4	—	—	—	—
63	*Siphia parva* (Bechst.)	1–3	1	1	—	—	—	—	—	—	—	—	—
64	*Phyloscopus collybita* Vieill.		1	1	—	—	—	—	—	—	—	—	—
65	*Phyloscopus trochilus* L.		1	1	—	—	—	—	—	—	—	—	—
66	*Parus caeruleus* (L.)		1	1	—	—	—	—	—	—	—	—	—
67	*Parus major* L.		1	1	—	—	—	—	—	—	—	—	—
68	*Chlorospiza chloris* Bp.		1	1	—	—	—	—	—	—	—	—	—
69	*Corvus cornix* L.	30–50	1	1	—	—	—	—	—	—	—	—	—
70	*Porzana parva* (Scop).	50–100	2	2	—	—	—	—	—	—	—	—	—
		7 600–10 000	42	22			626		74		1		

racter due to the authors coming to the lake for a short time only. More systematic observations started only in 1927 when a branch of the Bird Migration Research Station was established at Drużno. Of the Polish researchers Karczewski (1950, 1952) continued observations here for a few years right after the war when the waters of the lake expanded very widely because of damage to the protective walls.

The lake lies on the migration route, and as it is shallow and very strongly eutrophized, it attracts a huge number of birds. During my many visits during three years I could repeatedly observe larger and smaller accumulations of various bird species over the lake. In the time of autumn migrations in particular I used to see flocks of duck anything up to several thousands strong gather into passage trains.

Ornithological observations at Drużno were made by Dr. Krzanowski in 1950 and partly 1951, and by mgr J. Pinowski in 1951, their reports supplying a basis of the ornithological characterization below. According to Krzanowski's estimates, there are far more birds at Drużno Lake than at the famous „bird" lakes, Łukniańskie and Nordenburskie (alias Seven Island Lake). Ban on hunting sport at Drużno in 1951 very favourably affected the condition of birds. In the first post-war years, the protection of birds was not strictly observed and the state of protection improved again in 1949 and 1951. In spite of the great number of species, the bird population is now smaller than it used to be. What contributed to this was not only war time conditions, a change of the character of the lake brought about by the destruction of the dams directly after the war, the destruction of birds and their nests by poachers, a nuisance brought under control only in normal post-war conditions, but first of all more durable and stronger factors such as changes in the plant aggregate at the lake, which entail repercussions on the avifauna and their relation with the lake. Thus, e.g., the deepening of the Canal from 3.14 to 4 m has occasioned higher elevations and periodic oscillations in the water level. A very considerable amount of water has been exchanged with the Canal and the Bay during the changes. This undoubtedly tells on plankton, ichthyofauna and avifauna. As regards birds, such oscillations make their feeding either easier or more difficult, depending on the species. High water overflows some nests (*Larus minutus*), while low water makes them accessible to predatory animals. The influence of the

sea, and, according to others, of the factory sewers of the town of Elbląg nearby checks the growth of subaqueous vegetation. The phenomenon has let itself be distinctly felt from the 1914—1918 war onward so that since 1926 the annual weeding and mowing of the vegetation has been discontinued. According to the findings of the German authors Station VII had up to World War I been overgrown by *Sparganium ramosum,* while today *Nuphar luteum* grows there. Also *Stratiotes* has disappeared in the northern part of the lake today, while it put serious obstacles to boats there in the first quarter of the present century. This has heavily told on the nestling of *Larus minutus, Chlidonias nigra* and *Cygnus olor.* As regards many bird species a difference may be observed between their condition in the 19th century or even the first decade of the 20th century with their present condition. I am not going into details of the characterization of these changes as I wish to characterize the population of birds connected with Drużno Lake in the present circumstances and to the extent necessary to explore the occurrence of main hosts of parasites at Drużno Lake.

Attempts at a quantitative treatment of the bird aggregate at the lake failed mainly because it was difficult to make observations. As migrations continue in the region all the time (Tischler, 1941), there is no ornitological stabilization (as already referred to when methods were discussed) and consequently only comparative data were made use of and even a relative parameter with a considerable error was accepted — the number of *Fulica atra* and *Anatidae,* undoubtedly the most numerous birds at Drużno. While insisting on all objections of a methodical character mentioned above, I believe that despite many difficulties it is possible to single out species dominant at the lake and decide which of them occupy a key position and which constitute elements of the second plane or even less important.

During their two-year observations (1950 and 1951), Krzanowski and Pinowski distinguished over 70 bird species of nine orders. The following three groups might be distinguished among these (Table I).

1. Species typical of the lake, occurring in greater numbers, mostly nestling and constituting clear dominants in relation to other representatives of the avifauna. There are 16 such species.

2. Less frequent species, i. e., occurring constantly at the lake, yet connected more loosely with it, less numerically represented

and playing a considerably smaller part in the circulation of parasites. There were 18 such species.

3. Migratory species or those passing at the lake, staying there periodically, not nestling there at least during the periods of observation and exploration. Some of them may appear even in larger flocks, yet generally groups of few or even single specimens were found. It is calculated that there are 37 or even more species in the group.

We are interested above all in the first group. *Fulica atra* ranks among the most typical of the representatives of the avifauna of Drużno Lake. It is, according to the observations made by the previous authors, the most numerous and characteristic bird at the lake and occurs in flocks of 100 to 150 or sometimes even more. Distributed throughout the lake, it keeps near Stations I, II and VIII, about the northern parts of the lake, in its largest accumulations. It was estimated that there were 3 000 to 4 000 *Fulica atra* in 1950 and 2 000 to 3 000 in 1951. These are very large quantities indeed.

Anatidae are another group of very characteristic representative of the avifauna, *Anas platyrhynchos* being most numerous among them. It constitutes an aggregate no less numerous at the lake than *Fulica atra*, but it is only from August onwards that its strength becomes more noticeable. Before that time its females hide in the reeds near the bank, while mainly drakes may be seen at the lake. Very general calculation shows that there were 2 000 to 3 000 *A. platyrhynchos* at the lake in 1950—1951.

Of other nestling birds, *Aythya nyroca* was found in larger numbers, in absolute figures constituting only a tenth part of the number of *Anas platyrhynchos*, and *Anas querquedula*, in general more numerous only from the third decade of July to September. *Aythya fuligula* and *Aythya ferina* are considerably less numerous, the latter appearing to be in a depression due perhaps to the disappearance of subaquaeous plants.

Sterna hirundo, *Larus ridibundus* and *Chlidonias nigra* constitute the third group of species typical and characteristic of the lake. The numerical relations of the birds hardly differ from each other. They used to be very common at the lake in the first half of the 19th century. Thus the colonies of *Larus ridibundus* numbered from a few hundreds to a few thousands of nests. Varying quantities of them have been observed in the 20th century, yet still

even before the war more were noticed than now. During our observations their number fell so considerably that their mass occurrence reported by the German authors seemed amazing to us. K r z a n o w s k i sees reasons for this very abrupt fall in a haphazard and plunderous removal of eggs by the people of the neighbourhood. The colonies of *Larus ridibundus* attract other bird species which feel more secure with their nests among shrill voices of masses of gulls screaming continuously and attacking at once any, even imaginary, enemy. With its decline fell the number of *Sterna hirundo, Chlidonias nigra,* and others.

Among *Podicipedidae, Podiceps cristatus* is the most numerous and typical, while other species, *P. griseigena, P. nigricollis* and *P. ruficollis* are scanty and seldom observed.

Except for *Fulica atra,* representatives of *Ralliformes* are far less frequent. Among *Ardeiformes, Ardea cinerea* and *Ixobrychus minutus* should be ranked with typical species. *Ardea cinerea* does not nest at the lake itself, but number of them keep to it as their feeding ground. *Ixobrychus minutus* seems to be far more numerous than the number of specimens observed implies. It is difficult to notice because of its secret way of life, but it may be assumed that it is more numerous on the evidence of parasites, of which metacercariae are often found in fish, particularly in fry (*Posthodiplostomum brevicaudatum*).

Predatory birds connected with water are on the whole poorly represented. The most common of these was *Circus aëruginosus,* once very numerous and now less frequent at the lake, owing to gradual extermination.

Various representatives of *Charadriiformes,* various predatory birds (*Circus pygargus, Milvus migrans*), some *Passeriformes* and others belong to a group of birds less frequent and more loosely connected with the lake. *Cygnus olor,* occurring at Drużno Lake constantly, though in small quantities, should also be assigned to this group. Specifically the group is slightly richer than the first but numerically it falls short of it considerably.

The third group, most loosely connected with the lake, observed either during the passages in a varying number of specimens, or appearing at the lake for some time, is the richest in species and, except a few species, most poorly represented numerically. As final hosts they play the least important part in the circulation of parasites. Various host species contain various fluke and tapeworm

Table II

The occurrence of tapeworms in the biocoenosis

Species	Total found
1. *Hymenolepis paracompressa* Czapliński	16 517
2. *H. spiralibursata* Czapliński	10 258
3. *H. paramicrosoma* Gąsowska	2 056
4. *Diploposthe laevis* (Bloch)	1 481
5. *Diorchis inflata* (Rud.)	1 373
6. *D. brevis* Rybicka	1 344
7. *Dicranotaenia coronula* (Duj.)	1 046
8. *Echinocotyle rosseteri* Blanch.	846
9. *H. compressa* (Linton)	834
10. *H. arcuata* Kowalewski	816
11. *Fimbriaria fascolaris* (Pall.)	740
12. *D. nyrocae* (Yamag.)	536
13. *D. stefańskii* Czapliński	458
14. *D. ransomi* (Schultz)	364
15. *Sobolevicanthus gracilis* (Zeder)	309
16. *Ligula intestinalis* (Zeder)	279
17. *H. furcifera* (Krabbe)	170
18. *Cladotaenia circi* Yamag.	160
19. *Sphenacanthus macrocephala* Lopez-Neyra	157
20. *Dilepis glareola* Dubinina	147
21. *Paricterotaenia porosa* (Rud.)	130
22. *H. anatina* (Krabbe)	127
23. *Sob. wiśniewskii* Czapliński	110
24. *Anomotaenia microrhyncha* (Krabbe)	66
25. *Aploparaksis furcigera* (Rud.)	47
26. *Sob. krabbella* (Hughes)	35
27. *Sob. octacantha* (Krabbe)	22
28. *Paradilepis scolecina* (Rud.)	900
29. *H. abortiva* (Linstow)	19
30. *Orlovilepis megalops* (Crepl.)	17
31. *Liga gallinulae* (v. Bened.)	not numerous
32. *Ap. elisae* Skrjabin	
33. *Ap. skrjabinissima* Spasskaja	
34. *Ap. filum* (Goeze)	
35. *Ap. crassirostris* (Krabbe)	
36. *Ap. fusus* (Krabbe)	
37. *An. hydrochelidonis* (Dubinina)	
38. *An. rustica* Neslobiński	
39. *An. trigonocephala* (Krabbe)	
40. *Angulariella beema* (Clerc)	
41. *Choanotaenia musculosa* (Fuhrm.)	
42. *D. danutae* Czapliński	
43. *D. spinata* Mayh.	
44. *D. parvogenitalis* Skrj. et Math.	
45. *Gryporhynchus* sp.	
46. *H. capellae* Baer	
47. *H. parvula* Kowal.	
48. *H. teresoides* Fuhrm.	
49. *Sob. bissaccata* (Fuhrm.)	
50. *Schistocephalus solidus* (Müll.)	
51. *Trichocephaloides megalocephala* (Krabbe)	

species but I have failed to establish any major influence of theirs on the character of the circulation of parasites in the biocoenosis. The findings have so far indicated that these parasites play the part of an additional, less essential and accidental element in the parasitocoenosis.

It may be estimated that the number of birds in spring and summer varies from 12 000 to 20 000. In autumn this number may periodically be far higher. It is a large number and only so strongly eutrophized a lake as Drużno may feed the birds.

In view of the varying value of each of the above groups in the circulation of parasites in the biocoenosis, they were examined in various numbers. Attempts were made to examine as many birds as possible of group one, typically connected with the lake, and one or several representatives of the other groups (Table I). No equal proportion might be obtained in practice, and consequently the number of shot-down species of group one varied from 1.5 to 15% of the total occurring in the biocoenosis but was much higher (1 to 25%) in the other groups. The birds examined totalled 348.

Table I represents a list of species and numbers of the birds occurring in the biocoenosis and examined, a qualitative list of the species and parasites found. The lists enable one to find out that the group of birds typical of the lake contains most species and specimens of parasites. There are among them a great majority of flukes, nearly all tapeworm species and all species of thorny-headed worms. An overwhelming majority of the parasites mass found in birds as final hosts is contained precisely in these bird species typical of the lake. Thus the avifauna illustrates the thesis that typical representatives of parasites of a given biocoenosis are contained in typical and common species of this biocoenosis. It is therefore important to determine typical representatives of a biocoenosis.

It is possible to ascertain typical fluke and tapeworm species only if a parasitofauna is determined accurately. Consequently, the intensity and extensity of invasion ought to be ascertained. As typical and common in a given biocoenosis parasites should be regarded whose intensity is high and extensity of occurrence wide. The number of specimens found in a possibly wide range and large number of hosts is the most objective measure.

There were 43 species among the flukes found in birds of the Drużno Lake biocoenosis (S u l g o s t o w s k a, 23), of which 14 can be regarded as typical, while 29 ranked with those occuring less frequently.

The following are typical and common species in the parasitofauna:

1. *Diplostomum spathaceum* (Rud.),
2. *Apophallus mühlingi* (Jägersk.),
3. *Echinochasmus coaxatus* (Dietz),
4. *Bilharziella polonica* (Kowal.),
5. *Monilifer spinulosus* (Rud.),
6. *Notocotylus attenuatus* (Rud.),
7. *Hypoderaeum conoideum* (Bloch),
8. *Cotylurus pileatus* (Rud.),
9. *Apatemon gracilis* (Rud.),
10. *Typhlocoelum cucumerinum* (Rud.),
11. *Catatropis pacifera* (Noble),
12. *Mesorchis pseudoechinatus* (Olsson),
13. *Echinostoma revolutum* (Frölich),
14. *Posthodiplostomum brevicaudatum* (v. Nordm.).

The following 29 species are less common and denoted as accidental in Sulgostowska's study:

1. *Echinoparyphium recurvatum* (Linstow),
2. *Tylodelphys conifera* (Mehlis),
3. *Psilochasmus oxyurus* (Crepl.),
4. *Echinosoma stantschynskii* Sem.,
5. *Diplostomum mergi* Dubois,
6. *Tanaisia fedtschenkoi* Skrjabin,
7. *Plagiorchis maculosus* (Rud.),
8. *Plagiorchis nanus* (Rud.),
9. *Cyathocotyloides* sp.,
10. *Paryphostomum radiatum* (Duj.),
11. *Codonocephalus urnigerus* Ginec.,
12. *Plagiorchis laricola* Skrjabin,
13. *Leucochloridium actitis* Mc Int.,
14. *Cotylurus cornutus* (Rud.),
15. *Eucotyle zakharowi* Skrjabin,
16. *Ophiosoma patagiatum* (Crepl.),
17. *Dendritobilharzia pulverulenta* (Braun),
18. *Tylodelphys clavata* (Nordm.),
19. *Echinostoma* sp. 3,
20. *Apharyngostrigea cornu* (Zeder),
21. *Strigea falconis* Szidat,
22. *Tracheophilus sisowi* Skrjabin,
23. *Cyclocoelum mutabile* (Zeder),
24. *Plagiorchis* sp.,
25. *Prosthogonimus ovatus* (Rud.),
26. *Cyclocoelum microstomum* (Crepl.),
27. *Sodalis spatulatus* (Rud.),
28. *Echinostoma* sp. 1,
29. *Echinostoma* sp. 2.

Among the tapeworm species estimated by the same method the following order of frequency may be accepted. Fifty-one tapeworm species were found in the biocoenosis of Drużno Lake (Table II).

Among these, fourteen species (Nos. 1-14) may be regarded as typical, another nine (Nos. 15-23) as less frequent, while the other twenty-seven (Nos. 24-51) as rare and non-typical of the biocoenosis. A discussion of these species is contained in the studies by Czapliński (1956) and Rybicka (1957).

Owing to their vast accumulation, specific and numerical, at Drużno Lake, birds dominate as final hosts over any other group of vertebrate animals. Among the tapeworm species found in final hosts, 90% occurred in birds and 10% in fish. The distribution of flukes is more even. Among the 68 mature specimens, 44 (64.7%) were found in birds, 12 (17.6%) in amphibians, and 12 (17.6%) in fish. The number of discovered species of cercariae approximated that of species found in final hosts. Among six species of *Acanthocephala*, two occurred in birds, one in amphibians, and three in fish. It follows clearly from this comparison that birds, chiefly those typical of Drużno Lake, decide the character of the parasitofauna throughout the lake biocoenosis. With the argument inverted, it may be maintained that the composition of the parasitofauna in a biocoenosis depends on the range of its hosts and the domination of a definite aggregate of hosts.

Amphibians and their parasites

Amphibians were collected by Kozłowski (1950) and Chodorowska (1951), approach to either of them being different. While attempts were made to collect possibly all representatives of the group living in the lake or on its banks in 1950, stress was laid on collecting representatives of water amphibians in 1951. Seven species were found in 1950 and only the most common three in 1951. In this connection the proportions between the species collected changed considerably.

In the host material representatives of twelve species of mature flukes, five species of metacercariae, one species of thorny-headed worms, and three species of nematodes were found.

Invasion by metacercariae species, whose mature forms lived in birds proved to be higher than that by species maturing in amphibians. Among the flukes maturing in amphibians the first six spe-

Table III

Amphibians collected at Drużno Lake

Species	No. of specimens collected		
	1950	1951	Total
Bufo bufo L.	10	—	10
Bufo viridis Laur.	1	—	1
Rana esculenta L.	41	163	204
Rana temporaria L.	19	29	48
Rana ridibunda Pall.	18	—	18
Rana terrestris Andrz.	44	47	91
Triturus vulgaris L.	1	—	1
Total	134	239	373

Table IV

Parasites found in amphibians

Mature species	No. of specimens
1. *Pleurogenoides medians* (Olss.)	3 124
2. *Diplodiscus subclavatus* (Pall.)	503
3. *Haematoloechus variegatus* (Rud.)	388
4. *Pleurogenes claviger* (Rud.)	319
5. *Prosotocus confusus* (Looss)	285
6. *Opisthioglyphe ranae* (Fröl.)	200
7. *Gorgodera cygnoides* (Zeder)	29
8. *Haematoloechus similis* (Looss)	26
9. *Haplometra cylindracea* (Zeder)	12
10. *Brandesia turgida* (Brandes)	9
11. *Polystomum integerrimum* (Fröl.)	7
12. *Gorgoderina vitelliloba* (Olss.)	2
13. *Acanthocephalus ranae* (Schr.)	600
14. *Rhabdias bufonis* (Schr.)	15
15. *Nematoda* varia	17
Species of metacercariae	**No. of specimens**
1. *Codonocephalus urnigerus* (Rud.)	many
2. *Tylodelphys excavata* (Rud.)	many
3. *Tetracotyle cristalina* (Rud.)	250
4. *Polyadena* metacercariae	26
5. *Echinostoma* metacercariae	8

cies (Table IV) were numerous. Although there is a fairly clear difference between *Pl. medians* and the other five species, all six should be regarded as typical and common in the amphibians of Drużno Lake. The other species were rare.

Fish and their parasites

The parasites of fish were examined by Kozicka. She found the following twenty-one fish species in the lake:

Table V

Fish species in Drużno Lake

Species	No. of specimens examined
1. *Esox lucius* L.	63
2. *Rutilus rutilus* L.	87
3. *Scardinius erythrophthalmus* L.	51
4. *Aspius aspius* L.	2
5. *Gobio gobio* L.	10
6. *Alburnus alburnus* L.	55
7. *Blicca björkna* L.	85
8. *Tinca tinca* L.	118
9. *Abramis brama* L.	123
10. *Rhodeus sericeus* Bl.	39
11. *Carassius carassius* L.	16
12. *Cyprinus carpio* L.	5
13. *Cobitis taenia* L.	1
14. *Misgurnus fossilis* L.	2
15. *Anguilla anguilla* L.	2
16. *Lota lota* L.	1
17. *Pungitius pungitius* L.	2
18. *Perca fluviatilis* L.	115
19. *Lucioperca lucioperca* L.	8
20. *Acerina cernua* L.	23
21. *Pleuronectes flesus* L.	

Six species proved to be the most characteristic and dominant among these. They made up the bulk of the samples in the following order: *Esox lucius, Abramis brama, Tinca tinca, Blicca björkna, Perca fluviatilis* and *Carassius carassius*. The other species were far less frequent or found their way to the lake by accident

(*Pleuronectes flesus*). With the exception of *Cyprinus carpio* and *Pleuronectes flesus* all of them were tested for parasites. K o z i c k a examined a total of 1 388 specimens of which 801 were fullgrown and 587 young fish, during the four years of her research (1950-53). Full examination, i. e., the examination of all organs was carried out on 1 023 specimens, while the other 365 fish were tested only for definite parasites. Fish of over one year of age were invaded in 94%, fry in 82%. Thus, the invasion was very high indeed on the whole.

Table VI

Fish as final and intermediate hosts

Group	Mature species	Larval species	Total
Protozoa	9	—	9
Monogenea	4	—	4
Digenea	8	12	20
Pseudophyllidea	6	3	9
Tetrabothridea	2	—	2
Cyclophyllidea	—	2	2
Nematoda	2	1	3
Acanthocephala	4	—	4
Hirudinea	1	—	1
Copepoda	3	—	3
Lamellibranchiata	—	1	1
Total	39	19	58

The following are the fish species of which most specimens were examined: *Abramis brama* (123), *Tinca tinca* (118), *Perca fluviatilis* (115), *Rutilus rutilus* (87), *Blicca björkna* (83), *Esox lucius* (63). *Alburnus alburnus* (55), *Scardinius erythrophthalmus* (51), *Rhodeus sericeus* (39).

Fish constitute an important link as hosts of parasites in the Drużno Lake biocoenosis as they are reservoirs of both species maturing in them and larval forms, and thus they are final hosts of some species and intermediate hosts of others. In the biocoenosis of Drużno Lake they proved final hosts of 35 species and intermediate hosts of 17 species of *Plathelminthes*. Important in the fishing industry are above all larval forms, particularly in cases of higher or mass invasion. As follows from K o z i c k a's research, they may cause serious damage to fry.

The following fish species have the highest number of parasitic species: *Scardinius erythrophthalmus* (9), *Abramis brama* (9), *Rutilus rutilus* (9), *Blicca björkna* (9), *Perca fluviatilis* (8), *Esox lucius* (6), *Carassius carassius* (5), *Acerina cernua* (5), and *Gobio gobio*. Other showed far fewer of them. The lowest invasion was shown by *Lota lota* (1).

Fifty-eight parasitic species were found in the fish of Drużno Lake. Table VI shows their species and their division into forms maturing in fish or making use of them as intermediate hosts.

Among the 58 species found in fish, 18 must be regarded as dominant in the Drużno biocoenosis, since they occurred en masse or were relatively numerous, others were represented only by scores of specimens. A half of them are larval forms. These species are listed in Table VII.

Molluscs and their parasites

Molluscs constitute an important link in the circulation of parasites in the biocoenosis. They are the only first hosts of the developmental forms of *Digenea*, hosts of many species of metacercariae and of some cysticercoids.

In the years 1950, 1951 and 1953, 9000 specimens of molluscs were found at Drużno. About a half were collected by the quantitative method, the rest by the qualitative method. Four of the 23 species collected belonged to *Prosobranchia*, 14 to *Pulmonata* and 5 to *Lamellibranchiata*.

Acting on the assumption that the percentage of occurrence of a given species in a biocoenosis is the best criterion in estimating their frequency, the latter was determined on the basis of the material collected by the qualitative method. No difficulties were encountered, as half of the material (4 577 specimens) came from samples collected by this method. The order of frequency of various species is as shown in Table VIII.

The following species should be assigned to the most common molluscs of Drużno Lake: *Bithynia tentaculata*, *Physa fontinalis*, *Dreissensia polymorpha*, *Acroloxus lacustris*. As shown by the decreasing percentage of their occurrence, the other species are increasingly scarce.

In establishing the above order two indications were followed. First, only living specimens were taken into consideration, next,

Table VII

Species of fish parasites dominant in Drużno Lake

Species	Number	Host
Mature forms:		
1. *Rhipidocotyle illense*+*Bucephalus markewitschi*	26 956	*Esox lucius, P. fluviatilis, L. lucioperca*
2. *Ergasilus sieboldi*	15 910	*T. tinca, E. lucius, A. brama, Sc. erythrophthalmus* and others
3. *Dactylogyrus* sp.	1 485	*A. brama, R. rutilus, Sc. erythrophthalmus, B. björkna, C. carassius, A. aspius, A. alburnus, T. tinca*
4. *Asymphylodora tincae*	1 216	*T. tinca*
5. *Bunodera luciopercae*	864	*P. fluviatilis, L. lucioperca E. lucius, A. cernua*
6. *Glochidium*	531	*P. fluviatilis, A. brama, Sc. erythrophthalmus* and others
7. *Acanthocephalus lucii*	488	*P. fluviatilis, A. cernua, E. lucius* and others
8. *Caryophyllaeus laticeps*	366	*A. brama, T. tinca, B. björkna*
9. *Camalanus lacustris*	271	*P. fluviatilis, A. cernua, E. lucius, L. lucioperca* and others
Larval forms:		
1. *Bucephalus markewitschi* + *Rhipidocotyle* sp.	18 672	*A. brama, R. rutilus, B. björkna* and others
2. *Tylodephys conifera*	29 217	*P. fluviatilis, A. cernua, R. rutilus, B. björkna* and others
3. *Diplostomum spathaceum*	3 269	*R. rutilus, A. brama, B. björkna* and others
4. *Posthodiplostomum scardinii*	2320	*Sc. erythrophtalmus, R. rutilus*
5. *Tetracotyle variegata*	2 234	*A. brama, B. björkna, A. cernua C. carassius* and others
6. *Posthodiplostomum cuticola*	1 842	*R. rutilus, A. brama, B. björkna* and others
7. *Metacercaria helvetica* XVII	883	*R. rutilus, Sc. erythrophtalmus* and others
8. *Tetracotyle* sp.	326	fry
9. *Tetracotyle* sp.	152	*P. fluviatilis*

the whole lake, and not its separate sections which did not show the average occurrence of molluscs. Both of these principles require explanation.

The determination of the frequency of occurrence on the basis of the tanatocoenosis of molluscs would have yielded other relations. *Anodonta piscinalis* and *A. cygnea* shells were found very frequently to cover the bottom in large accumulations at some places in the lake, particularly near the pumps. Their remains accumulated yearly brought in great quantities by the pumps from

Table VIII

Molluscs in Drużno Lake

Species	Collected by			Total
	qualit. method	%	quant. method	
1. *Bithynia tentaculata* L.	1 080	23.55	666	1 746
2. *Physa fontinalis* L.	746	16.30	305	1 051
3. *Dreissensia polymorpha* Pall.	617	13.40	150	767
4. *Acroloxus lacustris* L.	511	11.20	33	544
5. *Bithynia leachi* Shepp.	362	7.90	4	366
6. *Radix ovata* Drap.	194	4.20	356	550
7. *Spiralina vortex* L.	179	3.90	179	358
8. *Radix ampla* Hartm.	144	3.70	198	342
9. *Valvata piscinalis* Müller	117	2.40	96	213
10. *Planobris planobris* L.	97	2.10	275	372
11. *Limnaea stagnalis* L.	72	1.50	557	629
12. *Anodonta piscinalis* L.	66	1.40	18	84
13. *Coretus corneus* L.	63	1.35	729	792
14. *Planorbis carinatus* Müll.	55	1.20	22	77
15. *Sphaerium corneum* L.	55	1.20	303	358
16. *Segmentina nitida* Müll.	46	1.00	158	204
17. *Amphipeplea glutinosa* Müll.	44	0,95	26	70
18. *Bytyomphalus contortus* L.	43	0,90	21	64
19. *Anodonta cygnea* L.	34	0,75	6	40
20. *Radix auricularia* L.	26	0.55	106	132
21. *Pisidium nitidum* Yan.	17	0.36	18	35
22. *Vivipara vivipara* Müll.	5	0.10	60	65
23. *Stagnicola palustris* Müll.	4	0.09	138	142
Total	4 577	100.00	4 424	9 001

the drains to the lake. It might be supposed on the basis of this material, which undergoes destruction less easily and more slowly, that *Unionidae* were very common at Drużno. In fact they did not

however catch up with many other species and constituted the final items on the list of frequency of occurrence. This however became clearly evident only when nothing but living material was taken into account in determining frequency of occurrence.

The occurrence of many snail species as well as other hosts was connected with the differentiation of the stations and points. *Pulmonata* in particular chose overgrown places sheltered from the wind and the waves, and even those with definite plant species. Thus, points richer and poorer in various species might be found at the lake. The above remarks refer to *Prosobranchia* in a smaller degree. *Bithynia tentaculata* in particular commonly occurred in Drużno and was at the same time more evenly distributed. In determining frequency of occurrence for various species I eliminated the error which might be made in estimation by taking into consideration relations throughout the lake, i.e., at all stations and points where materials were collected.

In the summarily treated material there were quantitative differences among various species depending on the collecting method, quantitative or qualitative. The species which were scarcer in the lake but important from the point of view of the possibility of spreading parasites (e. g., *Limnaea stagnalis*, *Coretus corneus*), common in final hosts, were collected by the qualitative method, and consequently the number of specimens examined was much higher when compared with the average frequency of occurrence of these species in the biotope (Table VIII).

The ratio of the mollusc materials collected by the quantitative and qualitative methods respectively was 1 : 1. Yet noteworthy was the varying distribution of the invasion of molluscs by cercariae and metacercariae, depending on the collecting method. The molluscs collected by the qualitative method proved to be twice as strongly invaded (Table IX).

How can we explain this nearly twice as high relation of the invasion of molluscs in the quantitative collections?

The quantitative material came, as is usually the case, from points richer in molluscs. It was collected mainly in small recesses, narrow overgrown canals, inlets of the lake. Such places were protected against the waves and were often difficult of access to man because of being filled with vegetation. They usually abounded in snails and consequently were often visited by birds. As Table XI celarly shows *Echinoparyphium recurvatum*, *Echinostoma revolu-*

tum and tetracotyle *Cotylurus cornutus* were the prevailing cercariae and metacercariae in the material collected by the qualitative method. They were found in the snails *Limnaea stagnalis*, *Radix*

Table IX

Invaded molluscs collected by the quantitative and qualitative methods

No. of molluscs invaded by	No. of molluscs collected by the		Ratio	Total
	quantit. method 4 577	qualit. method 4 424	1 : 1	9 001
cercariae	188	411		599
metacercariae	274	562		836
Total	462	973	1 : 2	1 435

Table X

Parasitic species found in molluscs

Mollusc	No. of species of			Total	% of invasion
	cercariae	metacercariae	cysticercoids		
1. *Bithynia tentaculata*	17	5	—	22	14.1
2. *Coretus corneus*	10	3	—	13	46.7
3. *Limnaea stagnalis*	9	4	1	14	28.4
4. *Planorbis planorbis*	8	3	1	12	10.0
5. *Radix auricularia*	7	3	2	12	35.0
6. *Radix ampla*	6	3	2	11	32.8
7. *Physa fontinalis*	6	5	—	11	6.2
8. *Stagnicola palustris*	5	3	1	9	40.1
9. *Spiralina vortex*	4	1	—	5	4.0
10. *Sphaerium corneum*	4	1	—	5	10.6
11. *Valvata piscinalis*	4	1	—	5	5.6
12. *Radix ovata*	3	4	2	9	25.6
13. *Acroloxus lacustris*	3	2	1	6	9.7
14. *Bithynia leachi*	2	1	—	3	4.3
15. *Bathyomphal. contortus*	2	—	—	2	3.1
16. *Vivipara vivipara*	1	3	—	4	9.2
17. *Dreissensia polymorpha*	1	1	—	2	1.1
18. *Anodonta piscinalis*	1	—	—	1	7.1
19. *Anodonta cygnea*	1	—	—	1	12.5
20. *Segmentina nitida*	1	—	—	1	0.5
21. *Amphipeplea glutinosa*	—	—	—	—	—
22. *Planorbis carinatus*	—	—	—	—	—
23. *Pisidium nitidum*	—	—	—	—	—

ovata and *Coretus corneus*, which came mainly from places abounding in these species and falling under the discovered category of the material collected qualitatively. Hence a higher percentage of the invasion of snails by cercariae, metacercariae and cysticercoids. On the other hand the points at the lake, in which the material was collected by the qualitative method were not privileged in this respect.

The frequency of occurrence of hosts was an indicator only in the determination of the most typical cercariae of the biocoenosis of Drużno Lake. With respect to the kind of parasites (cercariae, metacercariae, cysticercoids) found in them, and particularly because of the exclusiveness of snails as hosts of cercariae, possibly great numbers of snails were examined. Some species of cercariae were rather specifically connected with various species of molluscs.

Various species of molluscs showed various quality as first hosts of flukes. With the exception of *Bithynia tentaculata* the frequency of occurrence of snails in the lake does not coincide with the number of parasitic species found in them nor with the frequency of their invasion. Table X shows the decreasing numbers of parasitic species in their hosts and the percentage of invasion.

Bithynia tentaculata, Coretus corneus, Limnaea stagnalis proved to be the best hosts, containing the highest number of parasitic species, yet the last two species were rather scarce at Drużno. Snails, which showed the highest percentage of invasion (*Coretus corneus, Stagnicola palustris, Radix auricularia, R. ampla, Limnaea stagnalis*, etc.) should be regarded as the most liable to invasion. The data presented in Tables VIII & X clearly indicate that the frequency of occurrence of snails did not coincide with that of their parasites in the biocoenosis nor with the liability of snails to invasion.

The total invasion of snails by cercariae, metacercariae and cysticercoids amounted to nearly 16%, and this amounted, in absolute figures, to 1,435 out of 9,000 specimens examined. The invasion of snails by cercariae alone amounted merely to 6.6%, the invasion by metacercariae and cysticercoids to 9.5%. If each of the species were examined separately, far lower figures for the percentage of invasion would be obtained. In some cases the examination of thousands of snails revealed a cercaria of a given species only once or twice (Table IX).

The above evidence shows that the determination of the fre-

quency of occurrence for various species of cercariae in the population of Drużno snails requires a more accurate definition of the criterion which was followed in singling out their species. I regarded as common those cercariae which occurred in each of the three years and in most of the research seasons. I regarded as scarce those which were found in one or two years and in small numbers on the whole. Moreover it seems to me that it is more important for the estimation of the degree to which a parasite is common and typical in a given area, if it occurs repeatedly in a few years, rather than heavily in one year. Many species of cercariae are not confined to one snail species only. In determining the frequency of occurrence the sum total of hosts collected by the quantitative method should be taken into account. Moreover for the sake of comparison, I quote absolute and relative figures for cercariae found in snails collected by the quantitative and qualitative methods and the sum total of parasites found in snails collected by the two methods (Table XI).

Following the above criteria two categories of cercariae were singled out: common and scarce. 26 species (Table XI, 1-26) were regarded as common, the other 28 as scarce and less typical. A total of 54 species of cercariae were found. The percentage of invasion is relatively small. Only three species of cercariae showed a higher percentage of invasion. And thus *Echinostoma revolutum* cercariae were found in 15.8%, *Rhipidocotyle* cercariae in 9%, *Xiphidiocercaria* of 20.VII in 8%. All other cercariae varied from 2.5% to 2.8% of cases of invasion and even fell to the order of tenths per cent. Thus a considerable number of cercariae regarded as common occurred only in 0.3 to 2.5% of molluscs. The meaning of these figures will be much more striking if we realize that only a few hundred or hardly a score out of thousands of snails living of the lake were invaded by a definite species of cercaria.

This clearly suggests the conclusion concerning the significance of molluscs in the circulation of flukes in the biocoenosis of the lake. Molluscs accumulated the first development stage of flukes and as a consequence of this role they were a fundamental element in the circulation of flukes in the biocoenosis. Yet the way of life of these animals, very limited as regards movement, hampered and confined their role in spreading parasitic species. This must have contributed in a high degree to flukes developing developmental accommodations towards splitting their ontogenetic cycle into

Table XI

List of cercariae in order of occurrence in snails collected by the quantitative and qualitative methods

Cercariae	Cercariae collected by				Total	%	No. of hosts examined
	quant. m.		qualit. m.				
	No.	%	No.	%			
1. *Ech. revolutum* cerc.	11	15.8	79	14.1	90	14.3	629
2. *Rhipidocotyle* sp. cerc. (*Bucephalus polymorphus* cerc.)	9	9.0	1	4.1	10	8.0	124
3. *Xiphidiocercaria* 21.VII.	6	2.4	22	2.5	18	2.7	1 003
4. *Xiphidiocercaria* 20.VII.	5	8.0	16	2.2	21	2.6	792
5. *Echinoparyphium recurvatum* cerc.	12	2,1	46	2,5	28	2,3	2 425
6. *Xiphidiocercaria* 22.VII.50	1	1.0	9	2.1	10	1.9	514
7. *Cercaria papillosa*	15	1.4	17	2.6	32	1.8	1 746
8. *Tylodelphys excavata* cerc.	1	1.6	12	1.6	13	1.6	792
9. *Tylodelphys cornifera* cerc.	2	0.6	8	1.7	10	1.5	682
10. *Apatemon gracilis* cerc.	40	2.8	17	1.0	57	1.3	4 248
11. *Xiphidiocercaria* 4.VII.	1	1.6	7	0.9	8	1.0	792
12. *Ech.* 17.VIII. cerc.	4	1.0	13	1.0	17	1.0	1 753
13. *Cercaria ephemera*	9	0.8	17	1.1	26	1.0	2 637
14. *Cotylurus cornutus* cerc.	1	0.7	4	1.2	5	1.0	484
15. *Cercaria virgula* 27.VII.50	10	1.0	6	1.0	16	0.9	1 746
16. *Cercaria helvetica* XVII	10	1.0	6	1.0	16	0.9	1 746
17. *Posthodiplostomum brevicandatum* cerc.	2	0.2	11	2.0	13	0.9	1 423
18. *Diplostomum spathaceum* cerc.	1	0.4	7	0.9	8	0.8	971
19. *Bunodera luciopercae* cerc.	1	1.8	3	0.5	4	0.7	558
20. *Cercaria ocellata*	2	0.1	6	0.5	8	0.7	1 103
21. *Cercaria helvetica* XXIV	1	1.6	4	0.5	5	0.6	792
22. *Cercaria imbricata*	4	0.3	7	1.0	11	0.6	1 746
23. *Xiphidiocercaria microcotylea* 17.VII.50	5	0.3	5	0.7	10	0.5	2 112
24. *Bilharziella polonica* cerc.	1	0.3	5	0.4	6	0.4	1 522

Table XI continued

Cercariae	Cercariae collected by quant. m. No.	%	qualit. m. No.	%	Total	%	No. of hosts examined
25. *Cercariaeum inermis*	11	0.4	7	0.6	18	0.4	4 065
26. *Cercaria dubia*	2	0.3	1	0.3	3	0.3	1 051
27. *Cercaria micrura*	2	0.2	2	0.1	6	0.1	1 746
28. *Cercaria cristata*	4	0.2	2	0.1	6	0.1	2 488
29. *Furcocercaria* 13.XI.	3	2.5	—	—	3	1.3	213
30. *Cercaria echinost.* 13.XI.	3	2.5	—	—	3	1.3	213
31. *Furcocercaria* 9.V.	3	0.5	—	—	3	0.5	544
32. *Cercaria laticauda*	—	—	4	2.9	4	2.9	142
33. *Furcocercaria gracilis*	—	—	12	1.6	12	1.5	792
34. *Xiphidiocercaria ornata*	—	—	5	0.4	5	0.4	1 150
35. *Cyathocotyle* cerc. 11.XI.	—	0.1	—	—	1		1746
36. *Cercaria virgula* 16.VIII.	2	0.1	1	0.1	3		1 959
37. *Cyathocotyle* cerc. 10.XI.	1	0.1	3	1.0	4		1 746
38. *Cercaria* (incistata 1)	1	0.1	2	0.3	3		1 746
39. *Xiphidiocercaria microcotylea* 17.VII.50	1	0.1	—	—	1		1 746
40. *Gorgodera vitelliloba* cerc.	—	—	6	2.0	6		
41. *Furcocercaria* 24.VII	—	—	2	1.9	2		
42. *Diplodiscus subclavatus* cerc.	—	—	3	1.1	3		
43. *Gorgodera cygnoides* cerc.	—	—	3	1.0	3		
44. *Furcocercaria* 23.VII	—	—	1	1.0	1		
45. *Xiphidiocercaria* 16.VII.53	—	—	3	1.0	3		
46. *Allocreadium isoporum*	—	—	1	0.9	1		
47. *Xiphidiocercaria* 16.VII.51	—	—	5	0.7	5		
48. *Halipegus ovocaudatus* cerc.	—	—	2	0.7	2		
49. *Cercaria helvetica* XXIX (7.IX.)	—	—	1	0.7	1		
50. *Cercaria helvetica* X	—	—	3	0.5	3		
51. *Cercaria helvetica* XV (furc. 13.VII.)	—	—	3	0.5	3		
52. *Cercaria* (incistata 2)	—	—	4	0.5	4		
53. *Cercaria gymnocephala* 26.VII.	—	—	1	0.1	1		
54. *Furcocercaria* 19.VII	—	—	1	0.1	1		

a few stages taking place in a snail (generation of sporocysts, rediae and cercariae) and the multiplication of the progeny in that host. A large number of progeny compensated in a high degree the immobility of the host as far as the possibility for them to secure the preservation of their species goes.

The number of cercariae species determined as common (26) was not much lower than that of common and typical mature flukes (39), found in final hosts. On the other hand, the discovery of the other almost equivalent amount of species of cercariae (28) in small numbers could not be related to the same number of mature fluke forms corresponding to them. Most probably these forms occurred less frequently or in less common host species. It was difficult to confirm this hypothesis since the development cycles of the majority of these cercariae were not known.

Below is a list of cercariae in order of the frequency of their appearance in the biocoenosis (Table XI).

A considerable part of cercariae (about 66% o) occurred in one host only, the other 34% were found in two to seven hosts. The fact is striking that the majority of cercariae regarded as common occurred in two or more hosts, and consequently a narrow specificity was shown by a minority of common species in Drużno Lake. On the other hand, a great part of species regarded as scarce were found in one host only. The question arises whether with a greater intensity of parasitic invasion in final hosts they would not occur in a greater number of mullusc species. But if we consider only the relations of the occurrence of common cercariae, the conclusion suggests itself that the specificity of cercariae is not so narrow as it had commonly been considered before, when snails were examined without taking into account the background of the whole biocoenosis. Especially striking was the descovery of some species in *Prosobranchia* and *Pulmonata* at the same time. These were the following: *Cercaria cristata (Bithynia tentaculata, Valvata piscinalis, Limnaea stagnalis), Apatemon gracilis* cercaria *(Bithynia tentaculata, Limnaea stagnalis, Bathyomphalus contortus, Segmentina nitida, Physa fontinalis, Acroloxus lacustris).* The above cases might lead to conceiving the suspicion that a few species of cercariae related to each other were confused, yet morphological analysis could not discover this.

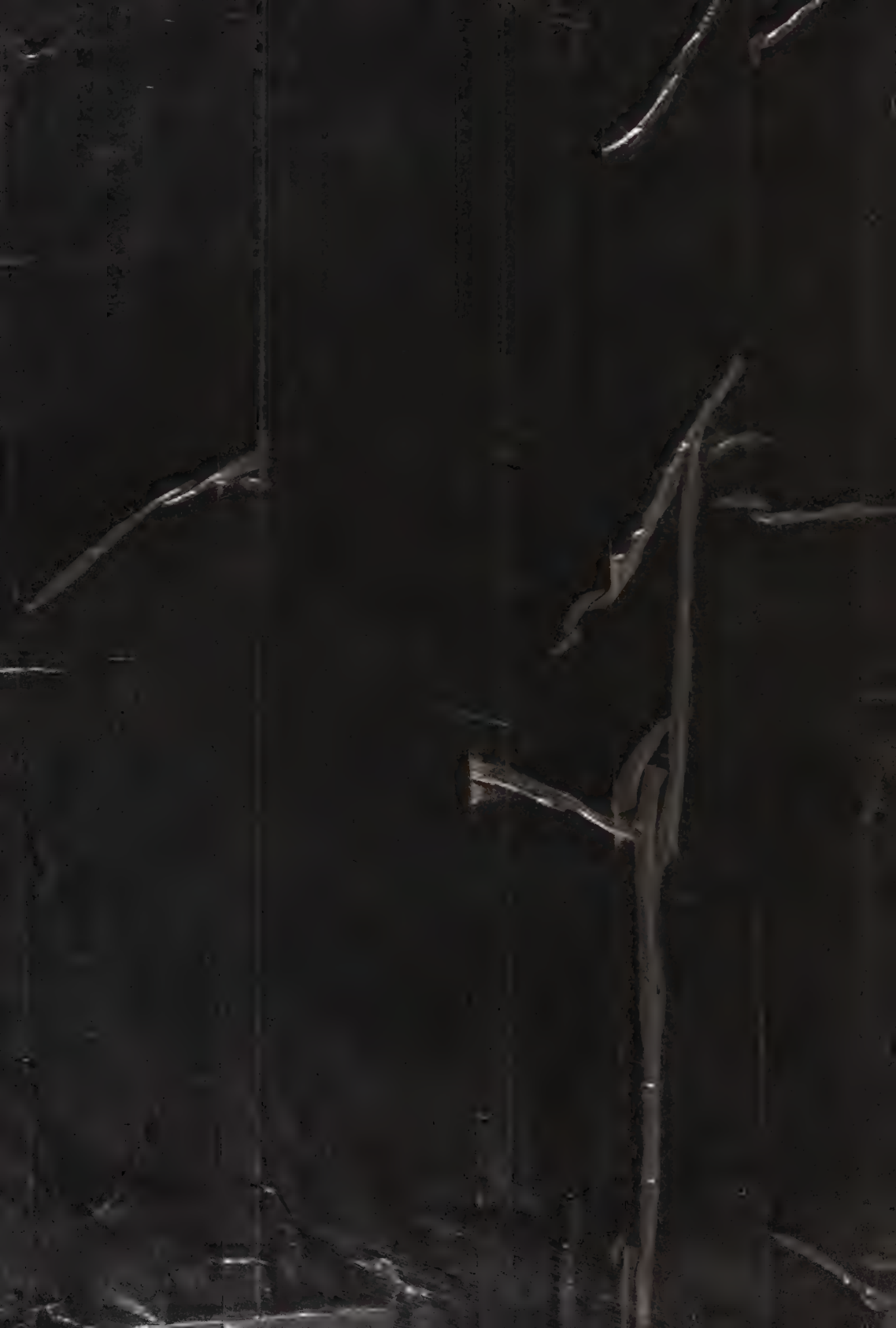
The majority of cercariae which had a few hosts usually showed specificity within the same family of snails, whether *Limnaeidae*

Table XIIa

Number of molluscs collected by means of quantitative (in numerator) and qualitative (in denominator) methods and number of cercariae, metacercariae and cysticercoids found in them

No.	Host	Molluscs collected				Number of molluscs invaded with cercariae				Number of moluscs invaded with metacercariae and cysticercoids				*Gymnocephala* cerc.	*Diplod. subclavatus* metac.	*Gorgodera* sp. metac.	*Asymphylodora* sp. metac.	*Xiphidionetacercaria*	*Tetracotyle*	*Prohemistomulum*	*Ech. lanciauda* metac.	*Ech.* 30. VIII. metac.	*Ech.* 1.IX. metac.	Cysticercoid	Number of moluscs invaded with cercariae, metacercariae and cysticercoids			
		1950	1951	1953	Total	1950	1951	1953	Total	1950	1951	1953	Total												1950	1951	1953	Total
1	*Bithynia tentaculata*	577 302	503 107	0 257	1080 666	28 28	24 7	0 27	52 61	31 10	29 2	0 61	60 73	7 13			0 11		9 6	2 0	9 88	33 55			59 38	53 9	0 88	112 135
2	*Bithynia leachi*	332 4	30 0	0 0	362 4	4 0	0 0		4 0	12 0			12 0									12 0			16 0			16 0
3	*Valvata piscinalis*	104 96	13 0		117 96	7 1	1 0		8 1	3 1			3 1									3 1			10 1	1 0		11 0
4	*Vivipara vivipara*	5 28	0 32		5 60		0 2		0 2	0 4			0 4				0 1				0 2		0 1		0 6			0 6
5	*Limnaea stagnalis*	61 207	11 107	0 243	72 557	22 30	2 19	0 74	24 123	8 7	0 5	0 12	8 24		1 0			0 1	3 11		1 9			3 3	30 37	2 24	0 86	32 147
6	*Stagnicola palustris*	3 42	1 72	0 24	4 138	1 3	0 9	5 1	1 13	1 6	0 46		1 52						1 28			0 1	0 19	0 3	2 9	0 55	0 1	2 65
7	*Radix ampla*	130 193	14 42	0 17	144 198	4 3	0 5		4 8	63 22	3 12		66 34					0 2	35 7			4 2		27 23	67 25	3 17		70 42
8	*Radix auricularia*	9 10	17 23	0 73	26 106	1 0	3 2	0 15	4 17	4 6	5 8	0 2	9 16						0 3			0 5		9 8	5 6	8 10	0 17	13 33
9	*Radix ovata*	173 70	21 82	0 204	194 356	5 2	2 4	0 33	7 39	48 16	5 13	0 13	53 42					1 0	2 8	0 1	2 14			48 19	53 18	7 17	0 46	60 81
10	*Amphipeplea glutinosa*	28 1	16 25		44 26					3 1	2 1		5 2						2 1			0 1		3 0	3 1	2 1		5 2
11	*Coretus corneus*	51 342	12 109	0 278	63 729	8 38	2 16	0 21	10 75	12 132	2 38	0 101	14 271					0 9	13 239		1 23				20 170	4 54	0 122	24 346
12	*Planorbis planorbis*	66 210	31 31	0 34	97 275	0 17	1 7	0 5	1 29	0 4		0 1	2 5	1 0					0 1		0 4			1 0	0 21	3 7	0 6	3 34
13	*Planorbis carinatus*	55 22	0 0		55 22																							
14	*Spiralina vortex*	176 75	3 52	0 52	179 179	5 2	0 1	0 3	5 6	2 1			2 1						2 1						7 3	0 1	0 3	7 7
15	*Bathyomphalus contortus*	33 18	10 3		43 21	1 0	0 1		1 1																1 0	0 1		1 1
16	*Segmentina nitida*	14 10	32 2	0 146	46 158	1 0			1 0																1 0			1 0
17	*Physa fontinalis*	654 88	92 29	0 188	746 305	6 2	2 1	0 17	8 20	23 1	1 1	0 12	24 14		1 0			0 3	2 0		21 10		0 1		29 3	3 2	0 29	32 34
18	*Acroloxus lacustris*	446 2	65 31		511 33	38 1	9 0		47 1	4 0	1 0		5 0			3 0						1 1		1 0	42 1	10 0		52 1
19	*Anodonta piscinalis*	58 12	8 6		66 18	3 1	1 0		4 1	1 0			1 0											1 0	4 1	1 0		5 1
20	*Anodonta cygnea*	34 4	0 2		34 6	5 0			5 0																5 0			5 0
21	*Dreissensia polymorpha*	151 144	456 6		617 160		1 0		1 0	1 0	7 0		8 0									8 0			1 0	8 0		9 0
22	*Sphaerium corneum*	29 261	26 42		55 303		1 13		1 13	1 23			1 23									1 23			1 23	1 13		2 36
23	*Pisidium nitidum*	9 9	8 9		17 18																							
		3208	1369	0	4577	139	49	0	188	217	57	0	274	8	2	3	0	1	69	2	34	62	0	93	35	106	0	462
		2096	812	1516	4424	128	87	196	411	234	126	202	562	13	0	0	12	15	305	17	70	69	21	56	363	211	398	973
	Total	5304	2181	1516	9001	267	138	196	599	451	183	202	836	21	2	3	12	16	374	3	104	131	21	149	719	317	398	1435

A detailed list of cercariae — see Table XII b



No.	Host
1.	*Bithynia tentaculata*
2.	*Bithynia leachi*
3.	*Vivipara piscinalis*
4.	*Vivipara vivipara*
5.	*Limnaea stagnalis*
6.	*Stagnicola palustris*
7.	*Radix ampla*
8.	*Radix auricularia*
9.	*Radix ovata*
10.	*Amphipeplea glutinosa*
11.	*Coretus corneus*
12.	*Planorbis planorbis*
13.	*Planorbis carinatus*
14.	*Spiralina vortex*
15.	*Bathyomphalus contortus*
16.	*Segmentina nitida*
17.	*Physa fontinalis*
18.	*Acroloxus lacustris*
19.	*Anodonta piscinalis*
20.	*Anodonta cygnea*
21.	*Dreissensia polymorpha*
22.	*Sphaerium corneum*
23.	*Pisidium nitidum*
	Total

or *Planorbidae*. However some of these cercariae showed a more distinct predilection for some hosts than for others. Thus, e.g., the above mentioned *Apatemon gracilis* cercaria, which had as many as six hosts, often occurred in *Acroloxus lacustris*, less so in *Physa fontinalis*, and very seldom in *Bithynia tentaculata*. In the same way *Radix ovata* seemed to be the most common first host of *Echinostoma recurvatum* cercaria, although the latter occurred in another six snail species of *Limnaeidae* and *Planorbidae*. *Xiphidiocercaria* 21.VII. had three hosts, but one of them, *Limnaea stagnalis*, is the most common first host, as the former was found 25 times in this host, while it occurred only once in *Radix ampla* and *R. auriculata* respectively. Thus, although a considerable amount of species of cercariae occurred in several hosts, one of these hosts was the main one, and others were auxiliary. This resembles the differentiation of *Copepoda* as intermediate hosts of larval forms of tapeworms (Michajłow). Table XII helps distinguish the main and auxiliary hosts of many species of cercariae. This may be of fundamental importance from the point of view of the survival of a species in various biotopes and biocoenoses.

Ten species of metacercariae were found in molluscs. Species of the family *Echinostomatidae* were prevalent among them (four species). Some *Gymnocephala* cercariae (two species) entered snails just as readily. The third group of larvae which entered molluscs consisted of some representatives of *Strigeidae*. At Drużno they were represented fairly numerously by the tetracotyle *Cotylurus cornutus* and far less so by *Prohemistomulum* sp. The tetracotyle *Cotylurus cornutus* occurred very commonly in *Coretus corneus*, where it amounted to thousands. The figures in Table XII present only the numbers of snails invaded; the intensity of invasion in each host invaded fluctuated from 1 to 400 and more. As regards metacercariae, Table XII shows that their specificity is very wide and the same species may occur in divergent families, and even orders, of molluscs.

A few species of cysticercoids of tapeworms of the family *Hymenolepididae* were also found in molluscs. They occured mainly in *Limnaeidae*, most of them in *R. ovata*, *R. ampla* and *R. auricularia*. Some of these cysticercoids were also recorded in *Copepoda* (Jarecka), but in far smaller numbers. A few or a few scores of specimens may occur in one mollusc host, multiple occurrence being more typical than single occurrence, which points out that

above all the representatives of the genus *Radix*, and only then *Copepoda* are hosts of *H. spiralibursata* and *H. paramicrosoma*.

As follows from the above list the molluscs of the Drużno biocoenosis are hosts of at least 67 parasitic species. A survey of these species shows that the common species of cercariae in the biocoenosis do not coincide with the common species of snails in the lake. *Echinostoma revolutum* cercariae were the most common of them. They lived in one host only *(Limnaea stagnalis)*, which ranked with rather poorly represented snails. In order to determine the composition of parasites of this species I had to collect them mainly by the qualitative method. *Xiphidiocercaria* 20.VII., the mature form of which probably occurs in frogs, ranked among the common cercariae, although its host, *Coretus corneus*, was even less common than the above mentioned snail. Its accumulations were scattered very unevenly, and although there were places in which many specimens might be found, there were also vast areas of the lake almost devoid of this species. Different examples may of course be quoted, where the frequency of occurrence of snails *(Bithynia tentaculata, Physa fontinalis, Acroloxus lacustris, Radix ovata)* did not coincide with that of cercariae *(Cercaria papillosa, Cercaria virgula* 27.VIII., *Cercaria helvetica* XVII, *Cercariaeum paludinae impurae, Apatemon gracilis* cercaria, *Echinoparyphium recurvatum* cercaria). In any event it was impossible to establish any parallelism between the predominance or typicality of representatives of hosts and those of cercariae in Drużno Lake.

As fluke cercariae occurred exclusively in molluscs, it was possible to find a greater number of species than that of mature flukes in final hosts. In relation to flukes, molluscs were a group of hosts accumulating species. A majority of larval species occurred in them, while other forms (metacercariae and mature forms) were scattered in the biocoenosis. This circumstance made it easier to determine the composition of flukes in the biocoenosis on the evidence of the list of cercariae, particularly those whose connection with final forms was known to us, rather than through examination of mature forms.

Arthropods and their parasites

Arthropods constitute an important link in the circulation of parasites in a body of water. Crustaceans appeared to be the first hosts of many species of bird tapeworms and of metacercariae whose

mature forms lived in fish. *Isopoda* proved to be hosts of metacercariae of bird flukes and intermediate hosts of *Acanthocephala* living in birds and fish. Insects were intermediate hosts of flukes of birds and amphibians.

1. *Crustacea*

Crustaceans were numerously represented in Drużno Lake. Research on parasites of *Copepoda* and *Cladocera* was conducted by Jarecka, parasites of *Ostracoda* were investigated by Sulgostowska and *Insecta* denoted by Klimaszewska. Crustaceans constituted the main component of the plankton sampled by

Table XIII

Crustaceans species	Number
Copepoda:	
1. *Macrocyclops albidus* (Jur.)	5 203
2. *Acanthocyclops viridis* (Jur.)	2 859
3. *Acanthocyclops vernalis* (Fisch.)	330
4. *Mesocyclops* (s. str.) *leuckarti* (Claus)	4 202
5. *Mesocyclops oithonoides* Sars	2 646
6. *Eucyclops* (s. str.) *serrulatus* (Fisch.)	894
7. *Eucyclops* (s. str.) *serrulatus* (Fisch.) var. *speratus* (Lill.)	272
8. *Eucyclops* (s. str.) *macruroides* (Lill.)	929
9. *Eucyclops* (s. str.) *macruroides* var. *denticulatus* (Greater)	1 321
10. *Eucyclops* (s. str.) *macrurus* Sars	950
11. *Cyclops insignis* Claus	73
12. *Eurytemora velox* (Lill.)	915
13. *Eurytemora lacustris* (Poppe)	269
Copepodit *Copepoda*	10 712
Nauplius *Copepoda*	3 164
Ostracoda:	
1. *Cypridopsis vidua* (O.F. Müll.)	2 992
2. *Cyclocypris laevis* (O.F. Müll.)	1 127
3. *Cyclocypris ovum* (Jurine)	70
4. *Notodromas monacha* (O.F. Müll.)	660

the quantitative and qualitative methods. Thirteen species of *Copepoda*, four species of *Ostracoda*, and about a score of *Cladocera* species were found among the 48,691 specimens of plankton examined. Below are quoted the numbers of specimens examined of *Copepoda* and *Ostracoda* (Table XIII).

Cladocera could not be denoted in detail as they had no larvae of tapeworms or flukes.

Macrocyclops albidus, Acanthocyclops viridis, Mesocyclops leuckarti, Mesocyclops oithonoides, Cypridopsis vidua, Cyclocypris laevis proved to be the most typical crustaceans of plankton. They were at the same time main intermediate hosts of the tapeworms occurring most frequently in *Anatidae* or fish (*Triaenophorus, Ligula*). Two heavily occurring species of *Ostracoda* (*Cypridopsis vidua* and *Cyclocypris laevis*) were main intermediate hosts of the tapeworms living in *Fulica atra*. Other tapeworm larvae were found in fish (*Gryporhynchus*), and partly in *Oligochaeta*.

Jarecka (1958) found in plankton larvae of twenty species of tapeworms of which eighteen were identified with mature tapeworms occurring in birds or fish at Drużno Lake. Larvae of the following tapeworm species were found:

1. *Triaenophorus lucii* (O. F. Müller)
2. *Ligula intestinalis* (Linné, 1758)
3. *Hymenolepis compressa* (Linton, 1892)
4. *Hymenolepis paracompressa* Czapliński, 1956
5. *Hymenolepis spiralibursata* Czapliński, 1956
6. *Hymenolepis paramicrosoma* Gąsowska, 1931
7. *Dicranotaenia coronula* (Duj., 1854)
8. *Sobolevicanthus gracilis* (Zed., 1803)
9. *Sobolevicanthus bisaccata* (Fuhrm., 1906)
10. *Orlovilepis megalops* (Creplin, 1829)
11. *Echinocotyle rosseteri* Blanch., 1891
12. *Echinocotyle clerci* Mathevossian et Krotov, 1949
13. *Echinocotyle druzniensis* cystic. Jarecka, 1957
14. *Diploposthe laevis* (Bloch, 1782)
15. *Diploposthe skrjabini* Mathevossian, 1945
16. *Fimbriaria fasciolaris* (Pall., 1781)
17. *Fimbriaroides intermedia* (Fuhrm., 1913)
18. *Diorchis ransomi* Schultz, 1940
19. *Diorchis inflata* (Rudolphi, 1819)
20. *Diorchis nyrocae* Yamaguti, 1935

Moreover two species of cysticercoids were found, which were not identified with mature forms, and a larva of the type *Gryporhynchus* in fish.

2. *Insecta*

12 800 insects were examined, over 7 700 of them in 1950 and about 5 100 in 1951. The bulk of them came from qualitative samples, as the insects found in quantitative samples consituted too scan-

ty a material. Larval forms prevailed among the specimens found. The mature forms examined were chiefly representatives of *Rhynchota* and *Coleoptera*. The number of species examined amounted to 30. Some of these were permanent and numerous components of the Drużno insectifauna, others occurred rarely. What was most interesting was that some representatives of, or whole, orders did not show the presence of larval forms of flatworms. *Sialis, Parapomyx, Agrion, Aeschna, Phryganea, Ryacophila, Tendipes, Cybister* occupied the first place among intermediate hosts of parasites, while the remaining genera had not been invaded in the lake. For illustration I give in Table XIV numbers of insects, larvae and imagines examined.

Larval forms of insects were the only ones to be invaded and *Aeschna, Agrion* and *Sialis* were the most common hosts among them.

Insects were found to contain exclusively metacercariae of flukes of which the mature forms lived in frogs and birds. Table XV shows the hosts and parasites found in them.

Varying numbers of metacercariae, from one to about a score, were found in one host. The metacercaria *Pleurogenoides medians*, found in various hosts, was the most common among them. Next came *Xiphidiometacercaria* II, which, judging by the common occurrence of its mature forms in frogs, might be *Haematoloechus variegatus. Prosotocus confusus*, too, ranked among the heavily occurring metacercariae. The metacercariae *Pleurogenoides claviger* and *Opisthioglyphe rastellus* were considerably less frequent. The denotation of the latter is not sure as they were identified by morphological and anatomical comparison with mature forms and not by analysis of the development cycle. Other larvae were found considerably less frequently. They were metacercariae of *Gorgodera vitelliloba, Xiphidiometacercariae* III, IV, V, VI and VII, *Gymnocephala* metacercariae, *Tetracotyle gracilis* and *Prohemistomulum* sp. metacercaria, totalling fourteen species together with those mentioned above. Metacercariae were found at all stations, both near the shore and at places far from it.

It follows from the above survey that insects as intermediate hosts at Drużno play a fairly important part, especially in respect to flukes of amphibians. Yet the percentage of invasion was very low, as of the total of 12 800 specimens examined only 2% were invaded. The intensity of invasion, too, is small on the whole, as a few,

Table XIV
The number of insects examind for parasites

Host	Number examined		
	1950	1951	Total
Larvae			
Odonata			
Agrion sp.	1 350	396	1 746
Aeschna sp.	28	104	132
Megaloptera			
Sialis flavilatera	678	1 135	1 813
Coleoptera			
Donacia sp.	3	10	13
Cybister roselli	10	5	15
Cybister laterimarginalis	9	5	14
Acilius sp.	8	—	8
Trichoptera			
Ryacophila potapomoides	—	627	627
Phryganea sp.	36	—	36
Limnophilus griseus	—	1	1
Polycentropidae	1 793	30	1 823
Ephemeroidea			
Baetis flumina	94	227	321
Cloeon dipterum	551	100	651
Caenis macrura	96	72	168
Caenis horaria	100	303	403
Potamanthus cinatus	—	12	12
Diptera			
Chironomidae	120	180	300
Tendipes plumosus	650	750	1 410
Tendipes semireductus	230	310	540
Stratiomyia sp.	18	13	31
Chaoborus cristallinus	24	7	31
Lepidoptera			
Paraponyx stratiotata	47	343	390
Larvae and imagines			
Coleoptera			
Hydrous piceus	11	1	12
Agabus sp.	46	—	46
Dityscidae	50	67	117
Rhynchota			
Notonecta glauca	142	51	193
Naucoris cimicoides	685	31	716
Nepa cinerea	77	31	108
Ranatra linearis	44	26	70
Corixa sp.	685	115	800
others	125	128	253
Total	7 710	5 090	12 800

and in the best case, about a score of metacercariae were found. Moreover the hosts appeared to be limited in number as they were exclusively larval forms of some species of *Odonata, Megaloptera, Ephemeroptera, Trichoptera* and *Diptera.*

Leeches and their parasites

Leeches constituted a numerous and very common group of animals in the lake. They were gathered from plants and benthos exclusively by the quantitative method and amounted to over 10 500 specimens. The material was denoted and examined for parasites by Dobrowolski.

The leech population was not only numerous but also specifically rich. During the period of two years (1950—1951) seventeen species and forms of leeches were found, in the following order of occurrence in the lake (Table XVI).

Three leech groups might be distinguished among the species and forms occurring in the lake. *Helobdella stagnalis* and *Herpobdella octoculata* belonged to the first of them, that of prevailing species. They constituted a half of the leeches gathered in the lake. The other groups were made up by the remaining species and forms of the genera *Herpobdella* and *Glossiphonia,* which supplemented the population as an additional element. Finally, the third group consisted of leeches (*Piscicola geometra, Hemiclepis marginata, Theromyzon tesselatum*), which either as parasitic forms could not be regarded as a component of the population of free-living leeches, or did not play any essential part as carriers of parasites.

Leeches proved to be main hosts of metacercariae of flukes. The tetracotyle *Apatemon gracilis* and the tetracotyle *Cotylurus cornutus* and *Prohemistomulum* sp. occurred in them. The first two also occurred in snails and *Oligochaeta.* The tetracotyle *Cotylurus cornutus* and *Apatemon gracilis* were the most common metacercaria species in Drużno. 2 034 leeches, 374 molluscs, and 196 *Oligochaeta* were invaded by them. The total of metacercariae of these species, found during two years in the biocoenosis, amounted to ower 11 500 specimens. Among these, leeches contained about 9 000 metacercariae, molluses under 2 000, and *Oligochaeta* about 700 specimens. This points out not only to the heavy occurence of these parasites, but also to the fact that leeches are the main intermediate carriers of larval forms. The high percentage of the invasion of intermediate hosts by metacercariae was not reflected in the invasion of final hosts. This

Tab

Comparison of invaded insects and *Asellus aquaticus* collected by means of
in denominator number

		Agrion sp.		*Aeschna* sp.		*Cybister laterimarginalis*		*Parapomyx* sp.	
	Year	1950-1951		1950-1951		1950-1951		1950-1951	
No.	No. of hosts examined	1350	396	28	104	9	5	47	343
1.	*Pleurogenoides medians* metacerc.	2/8	11/22	3/14	11/48			4/68	7/14
2.	*Pleurogenoides claviger* metacerc.								1/1
3.	*Xiphidiometacercaria* II		1/1		1/1				41/600
4.	*Prosotocus confusus* metacerc.	5/5		9/28					
5.	*Opistoglyphe rastellus* metacerc. (*Xiphidiocercaria* 4)					1/1			
6.	*Gorgodera vitelliloba* metacerc.								
7.	*Xiphidiometacercaria* III	1/1							
8.	*Xiphidiometacercaria* IV								
9.	*Xiphidiometacercaria* V					1/2			
10.	*Gymnocephala* metacerc.					2/2			
11.	*Xiphidiometacercaria* IV (*Plagiorchidae*)		1/1						
12.	*Metacercaria* VII 10.V.51								
13.	*Apatemon gracilis* tetracotyle				1/2				
14.	*Prohemistomulum* sp. metacerc.				2/2				

le XV

quantitative and qualitative methods (in numerator number of invaded hosts, of found parasites)

Ryacophila potapoi-moides	*Phryganea* sp.	*Sialis glavilatera*		*Tendipes plumosus*		*Tendipes semireductus*		*Asellus aquaticus*		Total
1950-1951	1950-1951	1950-1951		1950-1951		1950-1951		1950-1951		
627	36	678	1135	650	760	230	316			
1/1		14/50	103/800							156/1025
	1/1		5/92							7/94
			2/2			2/4				47/608
2/2								7/174	14/54	37/263
			1/1					1/1		3/3
1/1			3/5	1/1	4/4					9/11
							2/3			3/3
			1/1							1/1
				1/5	5/5		1/4			8/16
		3/3								5/5
		1/5								2/6
					13/16					13/16
										1/2
										2/2

divergence is replained by the fact that the specificity of mature forms of *Cotylurus cornutus* and *Apatemon gracilis* is relatively narrow as they were found in *Mergus albellus, Anas strepera, Aythya nyroca* (*Apatemon gracilis*) and in *Aythya ferina* (*Cotylurus cornutus*), while their metacercariae develop in leeches without any

Table XVI
Hirudinea species in Drużno Lake

Species	Number collected	% in the biocoenosis
1. *Helobdella stagnalis* (L.)	3 836	36.8
2. *Herpobdella octoculata* (L.)	2 012	19.5
3. *Herpobdella testacea* (Sav.)	981	9.4
4. *Herpobdella testacea* f. *nigricollis* (Brandes)	812	7.7
5. *Glossiphonia heteroclita* (L.)	598	5.7
6. *Glossiphonia complanata* (L.)	563	5.5
7. *Herpobdella testacea* f. *monostriata* (Lind. et Pietr.)	384	3.6
8. *Glossiphonia heteroclita* f. *striata* (Apathy)	358	3.4
9. *Glossiphonia heteroclita* f. *papillosa* (Braun)	346	3.3
10. *Glossiphonia heteroclita* f. *hyalina* (O.F. Müll.)	226	2.1
11. *Piscicola geometra* (L.)	113	1.0
12. *Theromyzon tesselatum* (O.F.Müll.)	103	1.0
13. *Hemiclepis marginata* (O.F.Müll.)	80	0.7
14. *G. complanata concolor* (Apathy)	25	0.2
15. *Boreobdella verucata* (O.F.Müll.)	14	0.1
16. *Haementeria costata* (O.F.Müll.)	2	
17. *Batrachobdella palludosa* (Carena)	1	
Total	10 454	100.0

special limitation, in a few species of snails (*Coretus corneus, Radix ovata, R. auricularia, R. ampla, Limnaea stagnalis*) and in *Oligochaeta*. Metacercariae may accumulate in intermediate hosts during a few years of their lives, and because of their very rare occurrence in the lake only a few of these hosts were examined. The intermediate hosts were a few years old and this contributed a more numerous representation of metacercariae than that suggested by the number of flukes in final hosts in which they occurred rather infrequently.

Oligochaets and their parasites

Oligochaeta constituted one of the most important component of the benthos of the lake. Eleven species were found in Drużno Lake of which eight were bottom species and at least three either plankton ones or those living on plants.

Limnodrilus hoffmeisteri, Illiodrilus hammoniensis, Tubifex albicola and *Tubifex tubifex* were the most numerous species. *Stylaria lacustris* and various species of *Nais* were the most numerously represented of *Oligochaeta* living on plants. Other representatives of this group were less numerous. As is known, exact denotation is not always possible in cases when reproductive organs are missing. Nothing more than genus (*Limnodrillus, Tubifex*) could be denoted for a high proportion of specimens found, which, in case a parasite occurred at the same time, made it difficult exactly to differentiate the specifity of the tapeworm species found. The total of *Oligochaeta* examined amounted to 20 800. The majority of specimens came from quantitative samples. The qualitative picking method with the help of a plankton net was applied mainly to *Stylaria lacustris* in which larvae of tapeworms of the genus *Monobothrium* were expected to be found, without much success however.

Oligochaeta, like many other hosts, occurred in foci in the lake. They did not form a homogenous evenly distributed population. There were places at the stations in which none of them were found and others where their concentrations of up to 1 000 and more specimens in one square metre could met. In places where they occurred, a mixture of representatives were encountered of all major species found in the lake.

Oligochaeta appeared to be hosts of larvae of four species of *Caryophyllaeidae* and of metacercariae of two species of the family *Strigeidae*. Among tapeworm larvae, *Archigetes sieboldi* was represented most numerously, next came *Caryophyllaeus laticeps, Caryophylloides fennica* and *Monobothrium*.

A vast majority of 437 larval forms could be safely denoted. Only 66 specimens (i.e., about 16.5%) were so young that they could not be classified. Some of them only might be supposed to belong to *Archigetes sieboldi* as a tapeworm occurring only in *Limnodrilus hoffmeisteri*. Among those which could be denoted, *Archigetes sieboldi* constituted a vast majority (about 55% of all specimens).

Among flukes, exclusively tetracotyle were found, which, on the basis of the dimensions and the character of their cyst, might be de-

Table XVII

Qualitative comparison of species of final, intermediate, and first hosts in the biocoenosis of Drużno Lake and qualitative comparison of parasite species

Host	No. of species		No. of exam. specimens	Number of species								
	in biocoenosis	examined		tapeworms			flukes			acanthocephalans		
				mat.	larv.	typ.	mat.	larv.	typ.	mat.	larv.	typ.
Vertebrates:												
Aves	70	19	388	54	—	14	43	—	14	2	—	1
Amphibia	7	7	373	—	—	—	12	5	9	1	—	1
Pisces	22	19	1 388	8	5	1	12	12	13	3	—	1
	99	75	2 149	62	5	15	67	17 metac.	36	6	—	3
Invertebrates:												
Mollusca	23	23	9 000	—	2*	2	—	54 cerc. 8** metac.	26	—	—	—
Oligochaeta	11	11	20 800	—	4	2	—	2** „	—	—	—	—
Hirudinea	17	17	10 500	—	—	—	—	3** „	—	—	—	—
Insecta	30	30	12 800	—	—	—	—	14***„	—	—	—	—
Isopoda	1	1	16 528	—	—	—	—	2 „	—	—	3	—
Copepoda	13	13		—	8*	—	—	2***„	—	—	—	—
Ostracoda	3	3	48 600	—	9	—	—	—	—	—	—	—
Phyllopoda	19	19		—	—	—	—	—	—	—	—	—
	117	117		—	21	4	—	54 cerc. 26 metac.	—		3	—
Total	216	192		62	26	19	67	54 cerc 43 metac.		6	3	3

* In *Mollusca* and *Copepoda* two species of tapeworms larvae were the same.

** In *Mollusca*, *Oligochaeta* and *Hirudinea* two species of metacercariae were the same.

*** In *Insecta* and *Copepoda* one species of metacercaria was the same (metacercaria *Gorgodera vitelliloba*)

scribed as the tetracotyle *Cotylurus cornutus* and *Apatemon gracilis*. They totalled 708. They were sometimes met together with tapeworm larvae and in these cases they were as a rule more numerous than the latter.

Conclusions and final remarks

The way, parasites occur in their first and final hosts in the lake suggests conclusions which seem to be the significance of regularities. The first three refer to all types of bodies of water and are of general import, while the others serve as a basis of the characterization of the parasitofauna of any eutrophic lake.

I. The importance of various hosts

The mode of the occurrence of parasites in their hosts reveals one of the most characteristic features of the circulation of parasites in a water biocoenosis, the importance of various hosts in their development cycle. This importance results from the regularity of the invasion of final, intermediate and first hosts. It becomes clear on the evidence of invasion that final hosts of tapeworms, flukes and thorny headed worms are a sort of concentrating sieve for parasites in a water biocoenosis, while intermediate hosts serve mainly to help these parasites pass to their final hosts proper.

This role of final and intermediate hosts has become clear only against the background of the whole biocoenosis and relations established by quantitative examinations. The biological meaning of such division of roles is simple. The final host alone is an environment in which organisms making fecundation possible may meet. Moreover the final host is the carrier of the young generation whether in the form of tapeworm proglottids or eggs of flukes and thorny-headed worms. The intermediate host again, helps, as one of the links in the alimentary chain of the biocoenosis, larval forms to enter their final host.

Table II makes it evident that a vast majority of species and specimens of tapeworms, flukes and thorny-headed warms parasitizzing in birds were massed in the alimentary tract of sixteen typical bird species. Larval forms of these parasites were scattered in intermediate hosts, a great number of which were examined (Table XVII). The invasion of intermediate hosts was extremely low.

From the point of view of preservation of species it is more ad-

vantageous that larvae should rather occur in small numbers in various intermediate hosts, but in more representatives of various species, since then they find more opportunities of coming across their final hosts. This explains the fact that intermediate hosts were scattered throughout the lake fauna without being specifically bound

Table XVIII

Bunodera luciopercae in various hosts

Year	First host	No. of invaded	% of invasion	Intermediate host	No. of invaded	% of invasion	Final host	No. of specimens	% of invasion
1950	*Sphaerium corneum*	3	1	*M. oithonoides*	5	0.22	*Perca fluviatilis*	586	19/44
							Lucioperca lucioperca	24	3/6
							Esox lucius	16	4/29
							Acerina cernua	8	4/21
							Tinca tinca	3	1/16
								647	31/116
1951	*Sphaerium corneum*	—	—	*M. oithonoides*	4	0.3	*Perca fluviatilis*	135	7/14
							Lucioperca lucioperca	5	1/2
								140	8/16

to a parasite in the same degree as final hosts were. They were replaced relatively easily by other species. Examples are supplied by *Crustacea*, *Insecta*, *Hirudinea*, *Oligochaeta* as intermediate hosts. This should be regarded as a reason not only for the occurrence of a greater number of intermediate host species but also for a lower congestion of parasites in them. And it also explains the phenomenon, fairly commonly observed, of a wider specificity and lower intensity of invasion in intermediate hosts. The mode of *Bunodera luciopercae* and *Ligula intestinalis* invasion may serve as an example of the relations in question in the biocoenosis of Drużno.

There were three hosts in Drużno Lake in the development of *Bunodera luciopercae*: *Sphaerium corneum* — first, *Macrocyclops oithonoides* — intermediate, *Perca fluviatilis* and other predatory fish — final. The distribution of parasites in their hosts is shown by Table XVIII. Moreover I found by experiment that *Daphnia pulex*, *Simocephalus expinotus*, *Eurycercus lamellatus* and *Notodromas monacha* might also be their hosts.

In the development of *Ligula intestinalis* the following hosts were found in Drużno Lake: *Mesocyclops leuckarti* — first, *Rhodeus rhodeus, Blicca björkna, Abramis brama, Rutilus rutilus* — intermediate, *Podiceps cristatus* and *Podiceps griseigena* — final. The distribution of the parasites in their hosts is shown by Table XIX.

Either of the above examples is very typical as far as the distribution of parasites goes. The final host was limited to one or a few definite species, there were more species of intermediate hosts (which testified to a wider specificity), while the number of plero-

Table XIX

Ligula intestinalis in various hosts

First host	No. of found larvae	% of invasion	Intermediate host	No. of found larvae	% of invasion	Final host	No. of parasites	% of invasion
Cyclops leuckarti	2	0.06	*Rhodeus rhodeus*	33	72.0	*Podiceps cristatus*	243	14/18
			Blicca björkna	28	26.3	*P. griseigena*	16	1/1
			Abramis brama	7	11.5			
			Rutilus rutilus	2	7.4			
				70				

cercoids and metacercariae in them was not large as a rule. The number of parasites in final hosts became greater as they eat many intermediate hosts. This regularity may be proved by most of the known development cycles.

Some modification was offered by the development cycle of *Rhipidocotyle* sp. (Table XX). Three hosts occurred in the development cycle of this fluke as well: *Anodonta cygnea* or *Anodonta piscinalis* as first hosts, various fish species as intermediate hosts, and predatory fish as final hosts. This development cycle differs from the former in a large number of metacercariae found in intermediate hosts. Without disproving the regularity of intermediate hosts showing a wider specificity, the example of *Rhipidocotyle* proves that the number of parasites in an intermediate host may sometimes be very high.

The role of first hosts of tapeworms approximated that of intermediate hosts of flukes. This is reflected in the generally low percentage and small intensity of invasion of first hosts by procercoids and cysticercoids. Yet there was a marked difference between first hosts of tapeworms and intermediate hosts of flukes. First hosts of tapeworms showed a clearer specificity and in most cases they were

Table XX

Rhipidocotyle illense in various hosts

First host	No. invaded / No. examined		Intermediate host	No. of larvae		Final host	No. of parasites	
	1950	1951		1950	1951		1950	1951
Anodonta cygnea	7/38	—	*Abramis brama*	6681	3550	*Lucioperca lucioperca*	53	37
			Rutilus rutilus	1276	491			
A. piscinalis	4/70	1/13	*Blicca björkna*	381	1500	*Perca fluviatilis*	719	79
			Scardinius erythrophthalmus	233	137			
						Esox lucius	10683	11029
			Gobio gobio	1	236	*Acerina cernua*	3	—
			Alburnus alburnus	35	14			
			Carassius carassius	24	—			
			Esox lucius	27	6			
			Acerina cernua	1	2			
			Lucioperca lucioperca	4	—			
			Perca fluviatilis	—	3			
	11/108	1/13		8663	5939		11458	11145

closely determined, while intermediate hosts of flukes were characterized, as mentioned above, by a wide specificity, usually limited to genera, sometimes to a family and even to a level corresponding to a wider taxonomic unit. The difference in the degree of specificity between first hosts of tapeworms and intermediate hosts of flukes was the most essential feature and at the same time a reflec-

tion of a different role of various categories of hosts in the biocoenosis. This difference had no doubt arisen during the evolutional development and had led to various accommodations.

II. The focal occurrence of parasites

Another peculiarity resulting from the distribution of parasitic material in a body of water is the focal occurrence of parasites. This means that the latter are not evenly distributed in various stations and points in the lake, but occur in a greater congestion at some points, in a smaller one at others and are totally absent in still others. Hosts, too, are characterized by such distribution.

Table XXI
Invasion of *Asellus aquaticus*

No. of place	No. of spots		*Asellus aquaticus*		No. of invaded *Asellus aquaticus*	
	exam.	with *Asellus aquaticus*	no. in 1 spot	total number	total in the place	in 1 spot
II	7	6	22—1438	2577	24	0—14
III	6	5	12— 685	857	8	0— 5
IV	5	3	390— 769	1584	25	0—11
V	7	5	366—1114	3539	65	0—35
VI	9	9	8— 303	818	5	0— 3
VII	8	4	27— 254	489	5	0— 5
VIII	8	7	20—2176	6644	74	0—40
Total	50	39		16528	206	

The focal occurrence of hosts and parasites bars the possibility of defining the average invasion at various stations and points. In order to present as accurately as possible the degree of invasion, we may describe it as ranging from the highest to the lowest, since the average is a term devoid of meaning which cannot serve to characterize quantitative relations in a body of water.

The focal occurrence of parasites is a phenomenon very characteristic of every type of body of water, also an eutrophic one, though it is least characteristic of the latter.

An illustration of focal invasion at Drużno Lake is offered by the mode of the invasion of *Asellus aquaticus* (Table XXI). *Asellus aquaticus* occurs very commonly in the lake, yet there are points at which it does not occur at all, although it occurs heavily close by.

It was found at 39 out of the 50 points examined and its number varied greatly from point to point. The number of *Asellus aquaticus* invaded varied from 0 to 35 between various points. Similar relations in the occurrence and distribution were met in all hosts. Further examples are supplied by the invasion of *Oligochaeta* (Table XXII), *Hirudinea* (Table XXIII) and *Mollusca* (Table XXIV). Focal invasion is confirmed even more distinctly by *Insecta* and *Amphibia* materials.

Table XXII
Invasion of *Oligochaeta*

No. of place	No. of spots		*Oligochaeta*		No. of invaded *Oligochaeta*	
	exam.	with oligochaets	no. in one spot	total number	total in the place	in one spot
II	7	5	2— 671	953	22	3—14
III	6	6	1—1007	2447	130	1—74
IV	5	5	115—3470	5186	179	4—83
V	7	7	20—2121	4105	110	0—55
VI	9	8	16— 432	1329	95	0—56
VII	8	8	56— 576	1579	106	5—71
VIII	8	8	2— 545	1218	27	1— 8
	50	49		16817	27	669

Focal invasion depends on, and results from, the distribution of final, intermediate and first hosts, while the distribution of hosts depends on biotical and abiotical factors. In this connection the focal occurrence of parasites is characterized by differences in degree. This is much more distinct in an oligotrophic and mezotrophic lake than in an eutrophic one. Thus in a mezotrophic lake there occur two biotopically different zones: the eutrophic bank and the mezotrophic pelagic zone.

The relatively insufficiently underlined focality of the distributions of both hosts and their parasites is a characteristic feature from the point of view of estimating the distribution of hosts and parasites in an eutrophic body of water. It leads, as a rule, to the possibility of the hosts being invaded in the same degree at all points at the lake. Consequently, the parasitofauna of intermediate hosts in particular, is potentially able to occur throughout the whole lake. The parasitofauna of a mezotrophic body of water is far more distinctly differentiated by the very fact of a greater biotopic differentiation.

III. The distribution of typical species

The third feature of the parasitofauna of every body of water is that it consists of two groups of species: typical and less typical of its biocoenosis. The typical species are at the same time more numerous and represented by more specimens, while those less typical are less numerous and represented by fewer specimens in their final, intermediate and first hosts.

Table XXIII
Invasion of *Mollusca*

No. of place	No. of spots		*Mollusca*		No. of invaded *Mollusca*	
	exam.	with molluscs	no. in one spot	total number	total in the place	in one spot
II	7	7	3—200	716	91	1—38
III	6	6	8—296	776	52	1—22
IV	5	5	47—154	518	54	1—40
V	7	7	119—400	313	75	2—16
VI	9	9	2— 87	335	19	0— 8
VII	8	8	6—112	251	26	2—11
VIII	8	8	2—206	648	115	1—36
Total	50	50		3557	432	

Representatives of typical species occur in host species typical of, and common in, the biocoenosis of a given body of water. The above thesis is particularly well illustrated by the parasitofauna of the Drużno biocoenosis, the character of which is mainly determined by its bird parasitofauna. Species typical of, and common in, the parasitofauna occur in birds, mainly of typical and common final host species.

IV. The invasion in an eutrophic lake

The entire material enabled the conclusion to be drawn that in the biocoenosis of Drużno Lake the following vertebrates occurred as final hosts in order of importance: birds, fish, and amphibians, and as first and intermediate hosts: molluscs, crustacean plankton, insects, oligochaets and leeches (Table XVII). Each of these groups had characteristic species and development stages of parasites.

The birds of Drużno Lake are final hosts of tapeworms, flukes and thorny-headed worms. 54 species were found among tapeworms, 43 among flukes, two among thorny-headed worms. Among these 99

species, 14 species of tapeworms, 14 species of flukes, and one species of thorny-headed worms were distinguished as typical of, and common in, the lake.

Amphibians were final and intermediate hosts of flukes. In them there were more species of mature flukes, while among larvae there occurred species living in birds as their final hosts. Next came *Nematoda* and *Acanthocephala*, while no tapeworms were observed. Among flukes common in the biocoenosis of the lake, six species of mature forms and three species of larval forms occurred in amphibians.

Division into mature parasites and larvae was very distinct in fish. Among tapeworms there occurred thirteen species, of which again eight mature in fish, and five species of larvae, among 24 species of flukes, one half consisted of species maturing in fish and another of larval species. Of 18 species of fish parasites regarded as typical of, and common in, the biocoenosis of the lake, one species belonged to tapeworms, four to mature flukes and nine to larval flukes.

Table XXIV
Invasion of *Hirudinea*

No. of place	No. of spots		*Hirudinea*		No. of invaded *Hirudinea*	
	exam.	with leeches	no. in one spot	total number	total in the place	in one spot
II	7	7	23—566	1660	354	3—226
III	6	6	125—346	1529	495	73—152
IV	5	5	87—714	1239	222	5—157
V	7	7	102—454	1238	353	9—159
VI	9	9	31—461	1918	184	0— 66
VII	8	8	14—489	1285	192	0— 85
VIII	8	8	41—403	1582	243	0— 74
Total	50	50		10451	2043	

In general it can be said that *Trematoda, Cestoda, Nematoda, Acanthocephala, Protozoa, Crustacea*, and *Nematomorpha* occur in Drużno Lake. A great variety of parasites is the first characteristic feature of the parasitofauna of the Drużno biocoenosis, just as it is, as proved by its example, of any eutrophic body of water.

It should be emphasized at the same time however that among this great variety of the fauna, representatives of *Trematoda* and

Cestoda, occurring as mature forms in birds, are most characteristic and numerous. They constitute a dominant element of the parasitofauna. This influences the composition of specimens maturing in final hosts and the composition of larvae occurring in intermediate hosts. This is another characteristic feature of the parasitofauna of an eutrophic lake. A total of 99 species of parasitic worms occurred in birds, while in the other vertebrates (amphibians and fish) there occurred a total of 58 species of flukes, tapeworms, and thorny-headed worms. The preponderance of the parasitofauna of birds is even more distinct, when mature and larval forms are considered separately. Out of the 135 species maturing in vertebrates, 99 did so in birds, 13 in amphibians, and 23 in fish. A similar preponderance might be observed in invertebrate hosts as far as larval forms are concerned. Among the 54 larval forms (cysticercoids, metacercariae, acanthellae) found in invertebrates, at least 30 (55%) underwent further development in birds. All this reflects an enormous preponderance of species parasitic in birds.

I believe that this phenomenon is characteristic not only of the biocoenosis of Drużno Lake, but also of eutrophic bodies of water in general. Therefore the opinion may be set forth that in eutrophic bodies of water, particularly in shallow ones, the parasitofauna of birds prevails and is characteristic of them.

In this connection the role of various animal groups in an eutrophic lake may be described. Birds prevail as final hosts, while amphibians and fish as final hosts become a supplementary element of a biocoenosis. The part of intermediate hosts is played by amphibians, fish, and in vertebrates. The role of amphibians and fish as intermediate hosts becomes very important. Among the 72 species of larval forms (cysticercoids, procercoids, plerocercoids, metacercariae, acanthellae) found in various hosts at Drużno Lake, 22 were found in amphibians and fish. The other 50 species were scattered among invertebrates.

I believe that if its most characteristic feature is to be stressed in the characterization of an eutrophic body of water, the preponderance of the parasitofauna of birds over other groups of vertebrates should be underlined.

Author's address:
Zakład Parazytologii UW
Warszawa, Krak. Przedmieście 26/28

LITERATURE

1. Czapliński B. — *Hymenolepididae* Fuhrmann, 1907 *(Cestoda)* Parasites of some domestic and wild *Anseriformes* of Poland. Acta Parasit. Polon., IV, 8, 1956.
2. Döring H. — Einiges über das Drausensee, seine Bewohner und Pflanzen. Pr. Prov. Bl. N. F., 1, 1844.
3. Döring H. — Über die Vögel und Fische des Drausensees. Pr. Prov. Bl. N. F., 3, 1847.
4. Dobrowolski K. — Pasożyty pijawek jeziora Drużno. Acta Parasit. Polon., VI, 5, 1958.
5. Dubinina M. N. — Parazitołogiczeskoje issledowanije ptic. Izd. Akad. Nauk SSSR. Moskwa-Leningrad, 1955.
6. Homeyer E. F. — Ornithologische Briefe. Berlin, 1881.
7. Jarecka L. — Plankton crustaceans in the life cycle of tapeworms occurring at Drużno Lake. Acta Parasit. Polon., VI, 2, 1958.
8. Karczewski Z. — Sprawozdanie z obserwacji ornitologicznych z nad jeziora Drużno. Bad. Fizjogr. nad Polską Zach., Poznań, 1950.
9. Karczewski Z. — Sumaryczne sprawozdanie z obserwacji za okres 1948-50. Bad. Fizjogr. nad Polską Zach., Poznań, 1952.
10. Kozicka J. — Diseases of fishes of Drużno Lake. Acta Parasit. Polon. VI, 20, 1958.
11. Krzanowski A., Pinowski J. — Ptaki jeziora Drużno. Sprawozdanie z badań za 1950-1951 rok (in manuscr.).
12. Lühe H. — *Trematoda.* In Brauer: Süsswasserfauna Deutschlands. H. 17, 1909.
13. Lüttschwager H. — Ornithologische Beobachtungen am Drausensee. Orn. Mon., Bd. 32, 1924.
14. Lüttschwager H. — Drausensee bei Elbing, seine Entstehungsgeschichte und seine Tierwelt. Danzig, 1925.
15. Lüttschwager H. — Von der Vogelwelt des Drausensees bei Elbing. Ber. Westpr. Bot. Zool. Ver., 58, 1931.
16. Mikulski J. St. — Jezioro Drużno — próba charakterystyki limnologicznej. Don. tymcz. Ekologia Polska, III, 1, 1955.
17. Mowszowicz J. — Zarys kwiatowej roślinności jeziora Drużno. 1954.
18. Rybicka K. — Tasiemce ptaków (excl. *Anseriformes)* jeziora Drużno. Acta Parasit. Polon., VI, 4, 1958.
19. Schultz M. — Die Vegetation des Drausengebietes. Schr. d. phys. — ökon. Ges. zu Königsberg, 22, 1, 1941.
20. Steiniger Fr. — Vogelparadises Drausensee. Leipzig, 1938.
21. Styczyńska E. — *Acanthocephala* of the biocoenosis of Drużno Lake. Acta Parasit. Polon., VI, 6, 1958.
22. Styczyńska E. — Some observations on the development and bionomics of larvae of *Filicollis anatis* Schrank. Acta Parasit. Polon., VI, 7, 1958.
23. Sulgostowska T. — Flukes of birds of Drużno Lake. Acta Parasit. Polon., VI, 3, 1958.

24. Tessendorff F. — Vogelwelt des Drausensees. Ber. Westpr. Bot. Zool. Ver., 39, 1917.
25. Tischler F. — Vögel der Provinz Ostpreussen. Berlin, 1914.
26. Tischler F. — Vögel Ostpreussens. 1, 2, Königsberg-Berlin, 1941.
27. Wesenberg-Lund C. — Contributions to the development of the *Trematoda Digenea*. II. D. Kgl. Danske Vidensk. Selsk. Skr. Naturw. og Math., Afd. 9, 3, Kobenhavn, 1934.
28. Wiśniewski W. L. — Zagadnienia biocenologiczne. Wiadom. Parazyt., 1955.
29. Wiśniewski W. L. — The development cycle of *Posthodiplostomum brevicaudatum* (v. Nordmann, 1832) Kozicka, 1958. Acta Parasit. Polon., VI, 9, 1958.
30. Wiśniewski W. L. — The development cycle of *Bunodera luciopercae* (O. F. Müller). Acta Parasit. Polon., VI, 11, 1958.
31. Wiśniewski W. L., Szymanik K., Bażańska K. — Tworzenie się struktury populacji u tasiemców. Československa Parasitologie [in press].

STRESZCZENIE

W latach 1950, 1951 i 1953 przeprowadzono zespołowe badania parazytologiczne na jeziorze Drużno (Druzno). Celem badań było: 1. poznanie krążenia pasożytów w biocenozie jeziornej Drużna, jako jeziora silnie zeutrofizowanego; 2. poznanie niektórych cyklów życiowych przywr, tasiemców i kolcogłowów; 3. poznanie składu ilościowego występujących gatunków pasożytów oraz wytypowanie wśród nich gatunków pospolitych i typowych dla biocenozy; 4. zebranie materiału pasożytniczego dla szczegółowego opisu poszczególnych gatunków.

Jezioro Drużno jest zbiornikiem zeutrofizowanym, płytkim, zarośniętym, posiadającym charakter litoralu. Znaleziono na nim licznie reprezentowaną biocenozę ptaków (70 gatunków), płazów (7 gatunków), ryb (21 gatunków), ślimaków (23 gatunki), owadów (30 gatunków), skorupiaków planktonowych (17 gatunków), skąposzczetów (11 gatunków) i pijawek (17 gatunków i form). Stosując przy połowach materiału metody ilościowe i jakościowe, zebrano liczny materiał żywicieli ostatecznych (kręgowce) i pośrednich (kręgowce i bezkręgowce), z których zbierano wszystkie pasożyty. W tabeli XVII podano ilość gatunków żywicieli, występujących w biocenozie, ilość przejrzanych żywicieli na pasożyty i ilość znalezionych gatunków pasożytniczych przywr, tasiemców i kolcogłowów, występujących w żywicielach ostatecznych i pośrednich.

Zebrany materiał pozwolił ustalić ogólne prawidłowości charakteryzujące krążenie pasożytów w zbiorniku jeziornym (punkty 1—3) i pozwolił scharakteryzować parazytofaunę zbiornika eutroficznego (punkt 4):

1. Rola żywicieli ostatecznych i pośrednich jest różna. Żywiciele ostateczni tworzą sito zagęszczające pasożyty, żywiciele pośredni, będąc jednym z członów łańcucha pokarmowego żywiciela ostatecznego, ułatwiają wniknięcie do żywiciela ostatecznego postaci larwalnych pasożyta. W związku z tym w żywicielach ostatecznych ilość osobników pasożytniczych jest duża i populacja ich liczna, w przeciwieństwie do żywicieli pośrednich, u których pasożyty występują w małym nasileniu. (Przykłady: *Ligula intestinalis* — tab. XIX; *Bunodera luciopercae* — tab. XVIII; *Rhipidocotyle illense* — tab. XX).

2. Pasożyty występują w biocenozie w sposób ogniskowy, co oznacza nierównomierne rozmieszczenie ich na stanowiskach w jeziorze (tab. XXI, XXII, XXIII, XXIV). Ogniskowe występowanie pasożytów zależy od nierównomiernego rozmieszczenia żywicieli ostatecznych i pośrednich.

3. W biocenozie określonego zbiornika występują typowe i nietypowe dla niego gatunki pasożytów. Przedstawiciele gatunków typowych występują w gatunkach żywicieli dla danej biocenozy typowych i pospolitych. Wśród pasożytów parazytofauny jeziora Drużno jako typowe i pospolite występują pasożyty ptaków.

4. Charakterystyka parazytofauny jeziora eutroficznego:

Jakkolwiek w jeziorze Drużno występują pasożyty należące do *Protozoa, Trematoda, Cestoda, Nematoda, Acanthocephala, Nematomorpha* i *Copepoda parasitica* — a więc bardzo duża rozmaitość przedstawicieli grup pasożytniczych — to najliczniejszymi i najbardziej charakterystycznymi przedstawicielami okazały się *Trematoda* i *Cestoda* występujące w ptakach. Stanowią one element dominujący. W ptakach występuje 99 gatunków robaków pasożytniczych dojrzałych, w pozostałych kręgowcach 36 gatunków (płazy 13 gatunków, ryby 23). W zbiorniku eutroficznym zaznacza się olbrzymia przewaga gatunków pasożytujących w ptakach jako w żywicielach ostatecznych. Rola żywicieli pośrednich przypada płazom, rybom oraz różnym przedstawicielom bezkręgowych, przede wszystkim skorupiakom planktonowym, ślimakom, owadom, skąposzczetom i pijawkom.